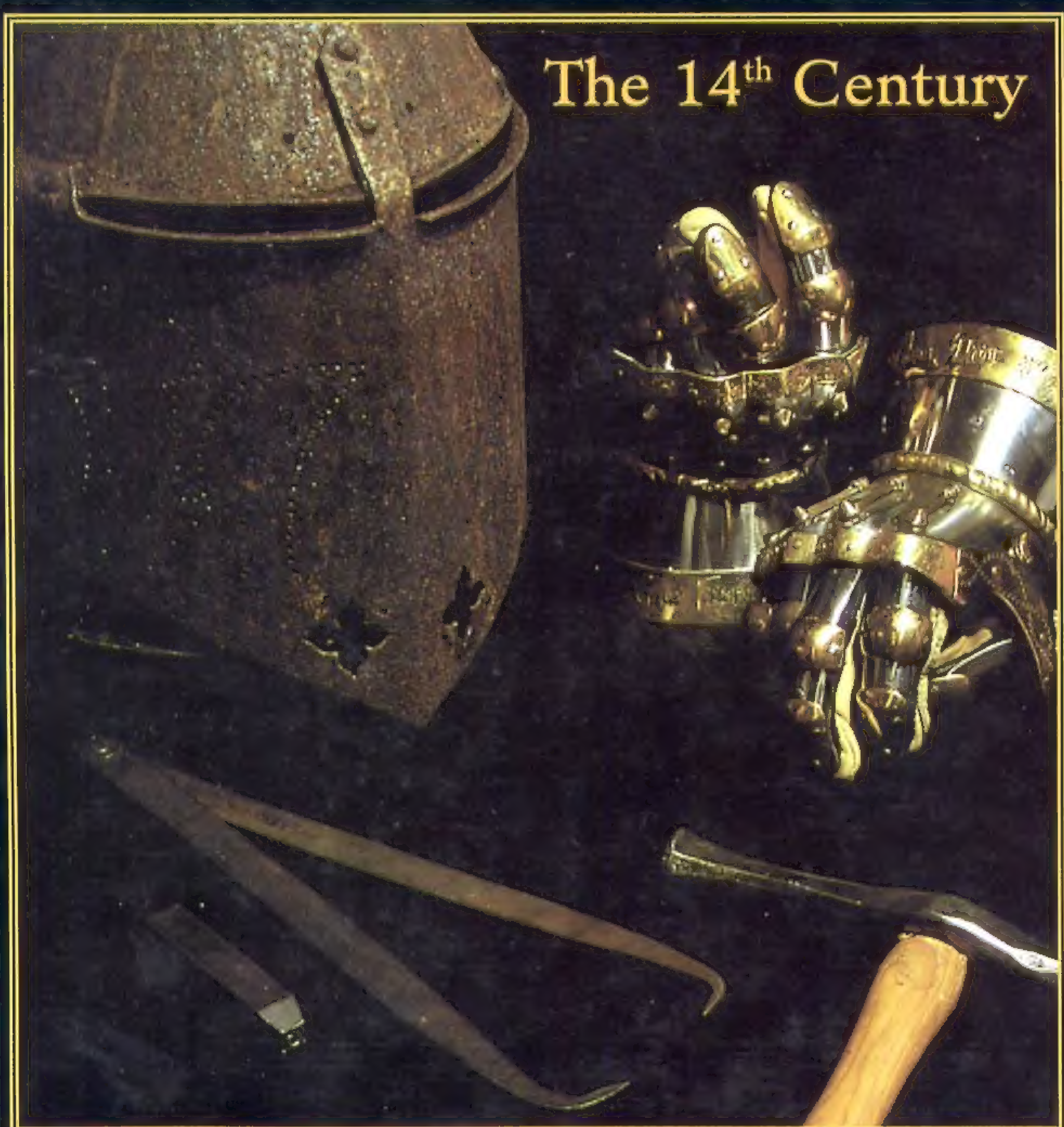
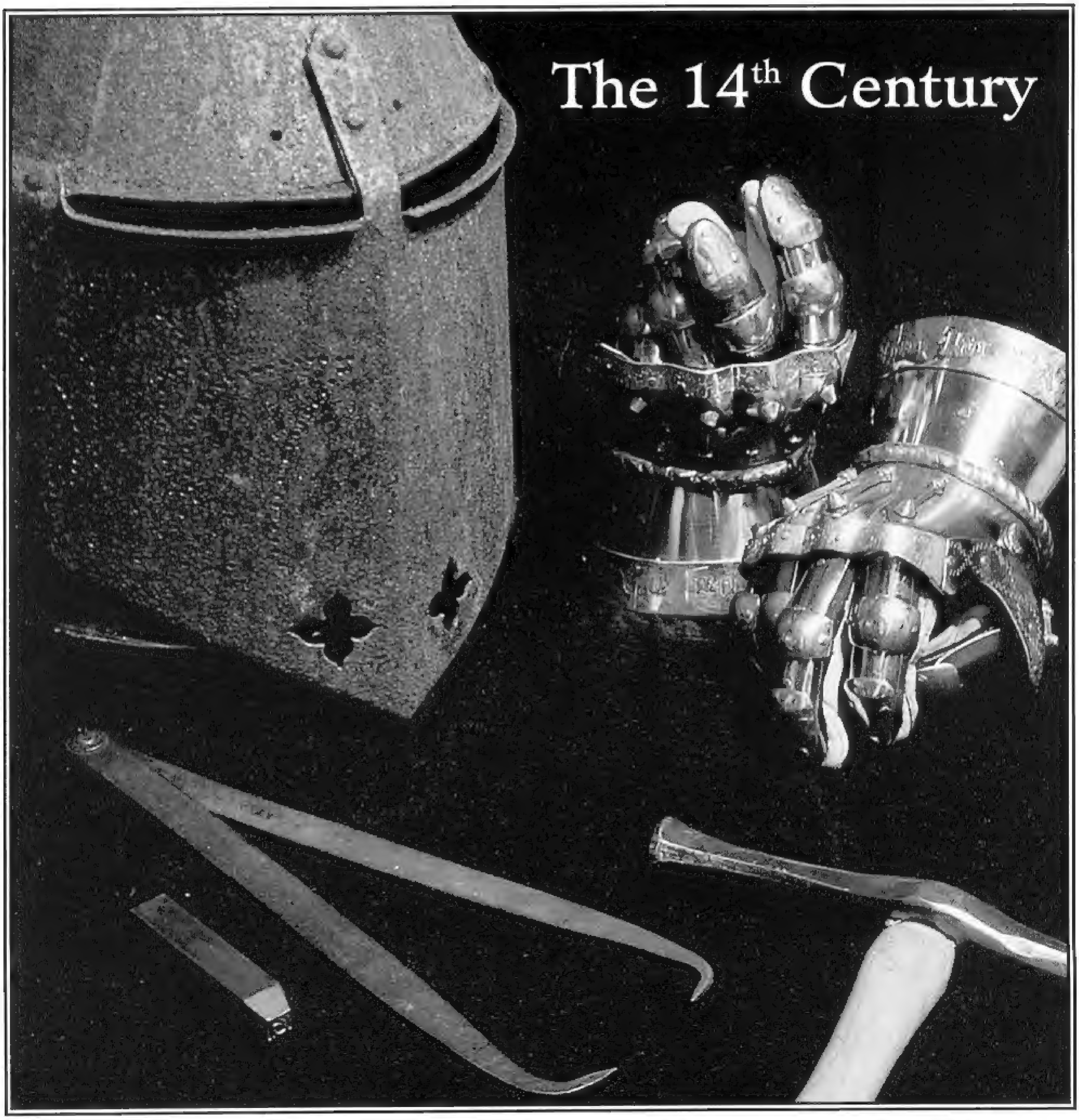
Techniques of Medieval Armour Reproduction



Brian R. Price

Foreword by David Edge · Contributions by Dr. Alan Williams

TECHNIQUES OF MEDIEVAL ARMOUR REPRODUCTION



Brian R. Price

Foreword by David Edge • Contributions by Dr. Alan Williams

Techniques of Medieval Armour Reproduction:
The 14th Century
by Brian R. Price

Copyright © 2000 by Brian R. Price

ISBN 1-58160-098-4
Printed in the United States of America

Publisher's Cataloging-in-Publication
(Provided by Quality Books, Inc.)

Price, Brian R.
Techniques of Medieval armour reproduction : the 14th century / by Brian R. Price. -- 1st ed.
p. cm.
Includes bibliographical references and index.
ISBN: 1-58160-098-4

1. Armour, Medieval--Design and construction.
2. Historical Reenactments--Equipment and supplies.
3. Tournaments, Medieval--Equipment and supplies.
I. Title.

U810.P75 2000 623.4'41
QBI00-500044

Published by Paladin Press, a division of
Paladin Enterprises, Inc., P.O. Box 1307,
Boulder, Colorado 80306, USA.
(303) 443-7250

Direct inquiries and/or orders to the above address.

PALADIN, PALADIN PRESS, and the "horse head" design are trademarks belonging to Paladin Enterprises and registered in United States Patent and Trademark Office.

All rights reserved. Except for use in a review, no portion of this book may be reproduced in any form without the express written permission of the publisher.

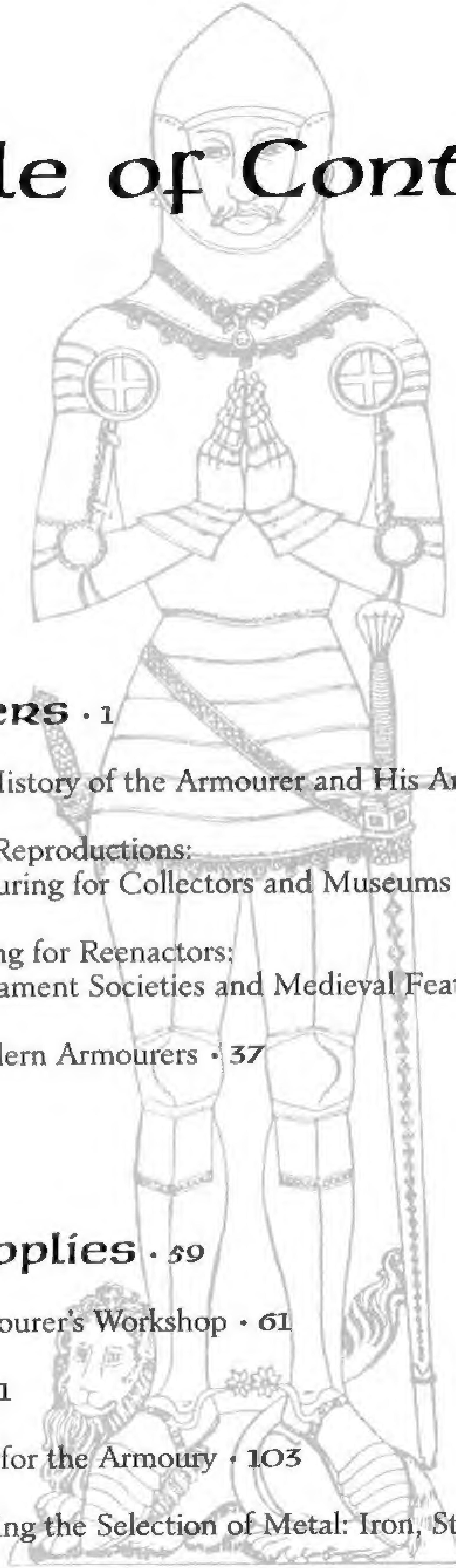
Neither the author nor the publisher assumes any responsibility for the use or misuse of information contained in this book.

Visit our Web site at www.paladin-press.com

Photo Credits
(copyrights reserved by the following)

Wade Allen, 2.6; *Bibliothèque Nationale de France*, 5.1; *Board of Trustees of the Royal Armouries*: 1.2, 1.6, 1.10, 1.11, 6.4, 6.10, 6.32, 17.2, 21.4 (top, middle), 23.3, 26.2, 29.5, 30.17 (left), 34.1; *British Library*, 19.2, 29.4; Charles Davis, 4.14, 6.46, 18.2, 23.12; Peter Finer, 2.3; Christian Fletcher, 4.18; Peter Fuller, 1.3, 1.4, 4.24, 6.40, 11.1, 29.3, 31.1, 31.5; James Gillaspie, 1.1, 4.20, 4.21, 16.1; *Historical Armed Combat Association*, 3.12; Tom Huguenin, 4.17; Brent Junkins, 3.4, 3.10, 3.11(left), 4.2, 4.3, 4.13, 20.11; *die Klauwerts*, 3.2; *Kunstammlungen der Veste Choburg*, 30.1; Karl Lieder, 21.3, 9.1, 21.5 (right); Robert MacPherson, 4.1, 4.26 (right) 30.1 (inset); Nathan Miller, 25.14; Steve Moffet, 3.14, 4.16; Theodore Monnich, 4.25, 5.2, 10.1; *Musée des Beaux Arts de Chartres*, 20.22; *National Gallery of Prague*, 3.1; Paragon Industries, 19.3; Joseph Piela, 4.19; Jessica Rechsthaffer, 4.15; Erik Schmidt, 26.13-16, 26.17-19; *Schweizerisches Landesmuseum*, 31.4; *Stadt Nurnburg Stadtarchiv*, 6.44, 22.2, 22.3, 26.3, 26.11; Aaron Toman or Wade Allen, 4.4, 4.5, 4.6, 4.7; *Trustees of the British Museum*, 6.33, 27.1; *Trustees of the Metropolitan Museum of Art*, 1.7, 1.9, 1.12, 21.5a; *Universitaltsbibliothek Ehrlangen*, 6.52; Robert Valentine, 4.22, 4.23, 29.8; Count von Trapp, 20.19, 29.1, 31.16, 31.17, 32.2; *Wallace Collection* I.1, 20.1, 20.7, 33.1, 33.2; Alan Williams, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6.

Table of Contents



Section Three
Techniques · 121

Section Four
Projects · 347

Appendices · 473

Index · 499

This book is dedicated to Aaron Toman,
aka Valerius Paencalvus, and the rest of the Valerius School
armourers, without whom this book would not exist.

Acknowledgments

No work this ambitious is completed by a single person. In addition to the inspiration, instruction, and friendship provided by Aaron Toman, to whom this book is dedicated, I must extend my warmest gratitude to all the people who helped make the dream of this book a reality.

I owe the lion's—or in this case lioness's—share of thanks to my loving wife Ann Marie. Without her patient encouragement, wrestling with the children, and wading through reams of paper, the book never would have been finished, owing to the pressures of everyday life.

Other very special thanks must go to a number of people whose individual support for the vision proposed in the book's conception have enabled it in unique and valuable ways. To my editor at Paladin Press, Jon Ford, who saw the potential of a few lines embedded in a light proposal, and whose patience has seen the arduous course taken finally reaching an end. To Cindy Tiger and Fran Milner for their fine layout and long hours. To Dr. Alan Williams, archeometallurgist at the Wallace Collection, who contributed not only the insightful article for Chapter 8 but a number of keen insights regarding probable medieval working techniques. Likewise to David Edge, curator of the Wallace, whose support for the whole idea of reconstructive archeology

with respect to reenactments has created a scholarly foothold for inspired practitioners of the chivalric arts. To Stephen Howe, librarian at the Royal Armouries at Leeds, for his continued patience and research assistance, going far beyond the call of duty. To Countess Cecily von Trapp, whose correspondence, translation, and photographs provided information unavailable elsewhere, all with the noblest of courtesy and warmth. To the armourers Charles E. Davis (Mallet d'Argent), Peter Fuller (Medieval Reproductions), James Gillaspie, Wade Allen, Robert MacPherson, and Erik Schmid, all of whom selflessly contributed their own knowledge and—more importantly—images of their work, without which this book would be far less rich. To Anthony Bryant, who contributed the measurement illustrations, and John Peterson, who did some crack Photoshop work. To Debora St. James and Robert Holland, who as members of the Company of Saint George have supported this endeavor for several years through their own research into equipment of the 14th and 15th centuries.

Others who helped contribute with their effort and support include Ian Eves, one-time curator of the Royal Armourers and Karen Watts, now a senior curator there; Robert Carol of the Metropolitan Museum of Art; Dr. Michael Eissenhaeur of Weste Coburg; Flora Madic of the Valeria Museum; the trustees of the Wallace Collection, the Royal Armouries; the Metropolitan Museum of Art; the British Library; the British Museum; the Swiss Landesmuseum; the Bibliothèque Nationale; Canterbury Cathedral; Claude Stefan, Musée des Beaux Arts de Chartre; Dr. Walter J. Karcheski Jr. of the Higgens Armoury; John Clements, Director of HACA; Greg Mele Director of SSI; Theodore Monnich, senior curator for the South Carolina State Museum; Karl Lieder, for the exquisite photographs taken of his collection of Valerius school armour; Admiral Steel; Peter Finer for the fine transparency; and the armourers who contributed images and encouragement for the idea—Brent Junkins (Anshelm Arms), Tom Justus (Master Eldrid Tremayne), Jessica Rechtschaffer, Joseph Piela (Lonely Mountain Forge), Bill Radford (Chapman & Radford), Tom Huguenin, Robert Valentine, Steve Moffet, and James Earley.

Thanks also to the Companions of Saint George, who encouraged the idea; Robert Reece, whose armour was delayed as the book was produced and for whom much of it was made; members of the other tourney companies, who have also lent their vocal support, specifically the Company of the Star, the Grand Company of the Peacocks, the Tenans of Noble Folly, the Company of Saint Michael, la Compagnie du Soleil, the Company of the Argent Angel, the Company of the Swan; members of the Klauwerts for their fine photograph; and the combatants of the Society for Creative Anachronism, whose enthusiasm for competitive tournament formats has both supported the bulk of reenactment armourers and enabled them to grow and learn.

Special thanks to Luke Apker, Greg Woznak, and Ladislav Kuzela, the old crew from Thornbird Arms who helped put our work on the map, and to my parents and in-laws, who continually encouraged the work's development. Lastly, thank you to Claude Blair and Sir Guy Laking, whose works have created the foundation upon which modern research and experimentation is conducted.

While all of these people contributed to this book, only I can take responsibility for the many errors that are bound to be found within. It is my hope that the existence of this work will propel others down the path of artistic pleasure that awaits a modern armourer, and it is my hope that in time their work will correct any errors propagated herein.

Foreword

As any schoolboy will tell you, medieval knights wearing full plate armour were eventually driven from the battlefields of Europe by the development of massed infantry gunfire. Much original armour, including some pieces that rank as outstanding works of art, survives in museums and private collections worldwide . . . end of story. Its original purpose fulfilled, why would anyone want to make any more? What useful function would such an activity serve? Nonetheless, hundreds of years later we are still fascinated by these dinosaurs of medieval warfare and almost inevitably find ourselves drawn particularly to the actual practice and mechanics of armour manufacture and wear. While perhaps no longer measuring output in tens of thousands, the craft of the armourer is still very much alive.

This is not merely a modern fad—the skills and excitement of the tournament were perpetuated in the 17^{th} and 18^{th} centuries by the delights of the Carousel, while in the 19^{th} century our Victorian ancestors became almost obsessed with knights and armour, fueled by retold tales of King Arthur and the novels of Sir Walter Scott. The wealthy antiquarian collectors of that era wanted to get in on the act, not just read about it. They dressed up in medieval-style clothing, furnished their

homes in "Gothic" taste, hosted medieval banquets and dinners, were painted in period costume, and sought generally to rediscover a preindustrial golden age of knighthood, honour, and chivalry. As well as wearing original armours, they commissioned new ones from the craftsmen of their day, which they wore to reenact tournaments and pageants. Similarly, in the early decades of the next century it was not enough for the great scholar-collectors, whose acquisitions form the basis of so many of our modern museums, to merely amass the stuff and display it in grand "baronial" style; there, in the archives of many of those same museums, can often be found the sepia-tinted photographs to prove that those giants of intellect and acquisitiveness, too, were drawn to try on for themselves their prized pieces of historic armour and be recorded in the act for posterity.

We also, in the 21st century, like the idea of actually *wearing* armour. We, like the Victorians before us, reenact battles and tournaments, but whereas they were perhaps seeking a more innocent golden age of romanticism, we yearn more to recapture something of the individual face-to-face contest of skill and endurance that played a much more immediate and vital role in medieval warfare than in its modern counterpart. This was perhaps less of a motive in the 19th century, still emerging as it was from the horse and musket era of warfare, but as little as 100 years later the practice of war had become very different, until today it is for the most part carried out at a distance, by machine or long-range projectile weapons, and in some instances literally by remote control. Many of us today, therefore, want to get back as near as we can to experiencing that face-to-face adrenaline rush, to unearth the truth about the actual battle experience of past centuries rather than to live the "golden age" myth. To discover the realities of living and fighting whilst wearing armour it would be impracticable to wear originals, even if this were ethically admissible; they would hardly ever fit and they would be difficult (if not ethically impossible) to alter, and as the whole efficiency of a full harness of plate depends upon tailoring it to the physiognomy of the individual, ill-fitting armour would teach us nothing and, for the historian at any rate, would therefore be a largely pointless scientific exercise (however much fun it might be). Besides, there is only a finite supply of the original stuff left, and it can only get steadily rarer as the centuries roll by. Enter the role of the well-made replica.

For museum professionals and modern armourers, the manufacture of replica armour can be a doubly rewarding partnership. Armourers can't make their own present-day versions without close reference to the original pieces, not to mention access to the archive and manuscript material preserved in museums, whilst museum scholars and academics cannot learn about the practicalities of armour performance, wear, and use without the constant experimentation of the reenactor/armourer enthusiast. The manufacture of armour is a craft, a technology, and an art. Only through a proper understanding of its methods can we fully appreciate the function, form, and history of armour, and only through a combination of study, analysis, observation, and practical experimentation can we hope to approach such an understanding.

For those of us who, like myself, are fortunate enough to work in a museum, or who live in a city crammed with great collections, libraries, and other such useful public institutions, developing, supporting, and furthering an interest in the arms, armour, and military history of a past era is relatively easy. But for many more, all over the world, the dubious authenticity of film and television is often the primary stimulus of their interest and knowledge, bolstered perhaps by the kind of imprecise and poorly researched general-interest arms and armour books that are too often all that the local library or bookshop can provide.

Brian Price's "nut-and-bolts-for-beginners" approach will be a welcome and refreshing resource for those new to the subject as well as appealing to those wishing to pursue a more practical and hands-on approach, and will

undoubtedly introduce many to the field who would otherwise be put off by impenetrable academic papers on the iconography of the armourer's art. Not everyone, of course, sets out to make armour purely in order to pursue serious historical research. One should never discount the "fun" element in any subject; not all reenactors and modern-day armourers will grow up to become museum curators (not that some of us curators have ever grown up anyway!), but that's not the point. For any subject to retain its fascination for successive generations, it needs to be large enough, varied enough, and uncertain enough (permitting study and research to be on-going, rather than end-stopped and stagnant) for all sorts of people to enjoy and benefit from their interest at every level. There is nothing at all wrong with making armour and recreating medieval-style battles or tournaments just because that's what you *like* doing! But the mere fact that you are doing it at all is keeping an interest in history alive, and *that* I think is of paramount importance.

One final point needs to be made. Many craftsmen, for reasons of their own, are jealous of the knowledge and skill they have acquired and guard it closely. Brian Price, together with the practicing armourers who have helped him along the way, has shown the sort of generosity in this enormous and comprehensive work which can only further interest, learning, and debate. He, and all those who have had a part in bringing this project to fruition, are therefore to be warmly congratulated. The study of arms and armour is too vast a subject, too exciting and too multifaceted, to be the exclusive preserve of the "ivory tower" museum academic. It is to be hoped that a work such as this will make the subject more accessible to a wider audience and, by stimulating their interest, breed a new generation of museum visitors, collectors, and amateur and professional armour-scholars, which will ensure both the study and the survival of historic arms and armour collections throughout the world.

David Edge
Armour Curator/Conservator
The Wallace Collection, London
June 2000

Preface

Few historical icons can match the evocative power of medieval armour. For generations, iron and steel carapaces surviving the ravages of time have enchanted soldiers, collectors, students, and the general public.

Forged largely from sheets of iron, beaten with hammer and stake into elaborate sculptures of defense, the knight's armour served him in several important ways. First, it provided a mobile harness that evolved to meet new weapons and tactics throughout the Middle Ages and into the Renaissance. The knight's harness served as life insurance in another sense as well, since the awesome expense for a complete *cap à pied* (head to foot) armour testified to his ability to pay a ransom if captured rather than face the death often dealt to the less fortunate. Finally, the shining armour and heraldic decoration worn by the knight connected him to a tradition attached over the centuries to a set of increasingly powerful ideals that sought to set the knight apart from the barbarity of mankind, beseeching him to strive toward a distant, unreachable ideal.

Looking into an empty harness on display at a museum, it doesn't take much imagination to find oneself transported back in time 500 years or more. Then as now, the knight's harness symbolized his prowess, his social station, his potential nobility of purpose. Our imagination

Opposite page: The sublime elegance of a German Gothic harness, c. 1490 (Photo courtesy of the Wallace Collection, London.)

easily fills that "empty" suit of armour with a knight of our own creation, an ideal, chivalric knight. In return, "he" conjures deep emotions within us, an immediate connection to romanticized ideals that have dwelt at the core of Western morality for the better part of a thousand years. How many of the thousands who pass through the great armour halls around the world think first of King Arthur rather than of the soldiers who actually wore the armour?

This connection between our modern sensibilities and the long-passed romance of the Middle Ages has been founded on a powerful literary tradition, strengthened by the existence and magic provided by surviving armour. The armour provides a tangible connection to ideals that might otherwise exist as mere words, grounding these ideals to a reality we can grasp by virtue of the armourer's skill. Through his art, he has succeeded in communicating across the ages, mooring the chivalric ideals to the iron sheet that is his medium, and through that sheet, to us.

It is in the practice of his craft, through the use of hammer, forge and stake, that the armourer can do more than merely mold steel to his will. If he is skilled enough, he can forge something of the chivalric ideal, something of his patron's essence, and sculpt the harness into a work of art. If he succeeds in capturing this elusive "spark," combining the armourer's function with the essence of character that transmits a message through the ages, then he has created art, much as a fine painting or sculpture preserves the soul of the subject.

Students, reenactors, and medievalists share this love of the armourer's art. Today, more than 400 years since the use of armour became obsolete, there is a growing resurgence of interest in the armourer's craft fueled by collectors, reenactors, and medieval martial artists.

In recent years, the price of armour available at auctions has steadily increased, and it has become nearly impossible to acquire authentic examples that date from before the late 16th century. Reproduction armourers have developed their skills to help fill this gap, working mainly in the 14th, 15th, and 16th centuries to create documented copies that will fill a missing piece in an enthusiast's —or even a museum's—collection.

Alongside these armourers, tournament reenactments have also grown in popularity. Large aggregate groups such as the Society for Creative Anachronism (SCA) have given wide-reaching public exposure to their form of tournament recreation. Smaller groups have emerged in parallel, focusing on a more authentic presentation of a given historical period. Today there are more than a hundred medieval reenactment companies spanning Europe, Australia, Canada, and the United States. Working within the parameters of these groups as laboratories for the resurrected Western martial arts, reenactment armourers have pushed the practical knowledge of what medieval armour might or might not have done by using and observing the product of their work in the field. Indeed, many of the more skilled armourers working in the United States are also accomplished "knights," welding their knowledge of metalwork with intimate, practical experience gained by using their work under the stress of real fighting.

As a combatant and armourer of long standing within the SCA, it has long been my desire to advance the quality of field equipment available to the reenactors in this massive group. Simultaneously, it has been my passion to seek to improve my skills, moving my pieces from reenactor class to reproduction quality, striving ever to improve the calibration of my eye and my skill with the hammer. Added to this, I have been a combatant within the SCA for more than 18 years, 12 of them as a knight. It is the fighting, combined with the silky lines of 14th and 15th century armour, that create the framework for the chivalric conduct I have written about in my first two books, *The Book of the Tournament* and *Pas d'Armes and Roundtables: Recreating Medieval Feats of Arms*.

Chivalric conduct and feats of arms, as practiced in the modern day, have recreated something of the medieval romances. As in the historical context, tournaments are used as a test of both prowess and character, a celebration of the knightly ideals as they are

understood within the context of our modern society. As was also true throughout the Middle Ages, we have adapted the ideals to meet the realities of modern life, striving through these efforts to educate as we entertain. In the end the goal is to make the combatants and members of the gallery better people as something of the ideal remains with them in their everyday lives.

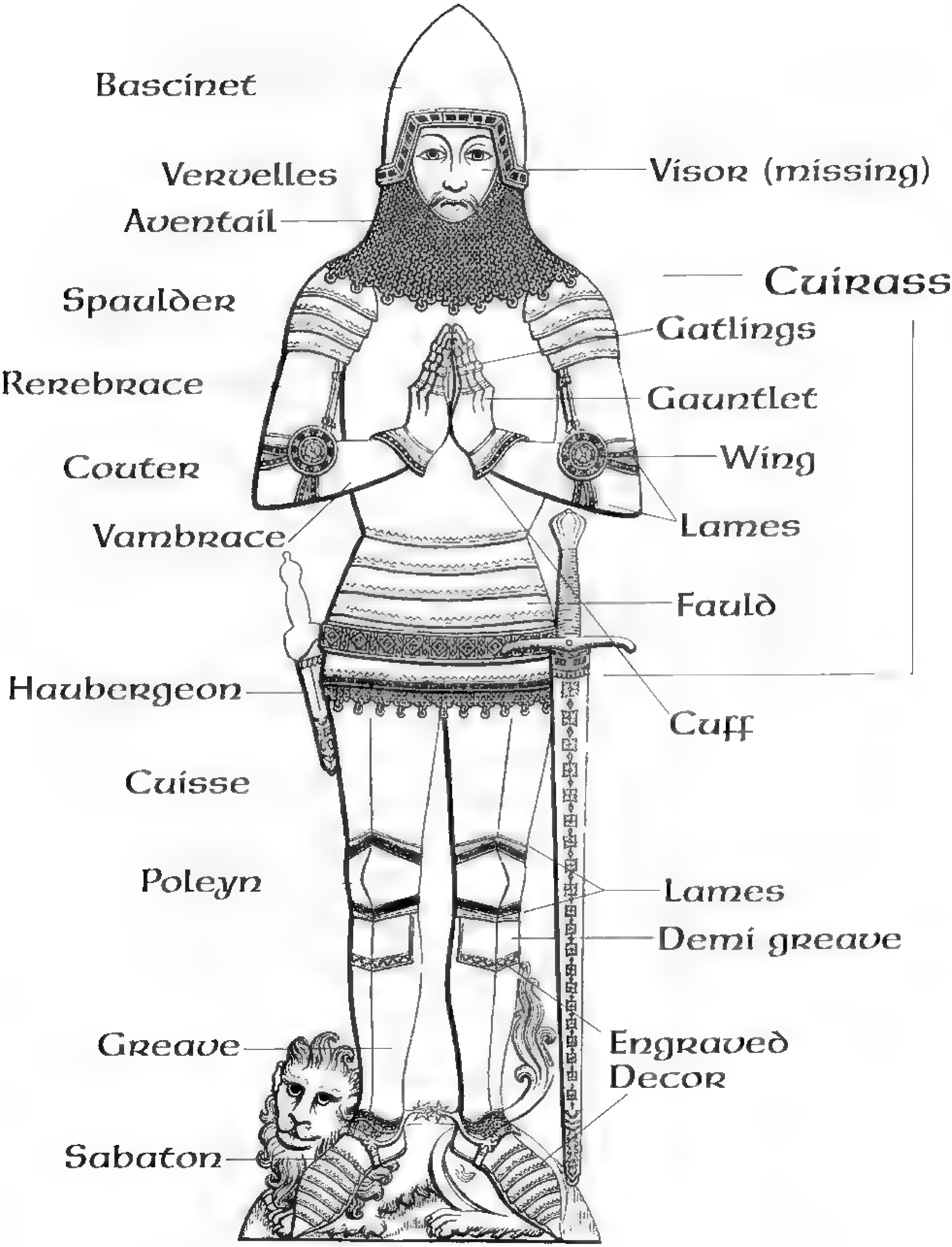
Added to this, there is something artistically satisfying about creating an elegant, powerful harness from a flat sheet of gray metal. Although the techniques shown in this book give a good many modern shortcuts, the real challenge is to produce pieces in as correct a manner as possible, using as few shortcuts as possible, striving to create a piece that is as close to the original as is feasible. Using these pieces under the full-contact combat styles I have practiced, there remains a great deal to be learned about how the medieval knight wore his armour, how it was made, and why some of the odd things we find in historical examples are as they are. All around, a fine challenge and a satisfying pursuit.

The purpose of this book is to provide a set of techniques, tips, and patterns through which a novice or early intermediate armourer can sharpen his skills to produce equipment from the 14th century. There is certainly a need for armour from other periods, but in order to keep this book focused and to encourage a cohesive field appearance, I have chosen to stay within the period most favored by the reenactment groups. Armour from the "transitional" period of the 14th century presents a variety of advantages to competitive béhourd-style reenactments, since the béhourd itself was popular during this period. As such, this book is aimed mostly at the reenactor but should also prove useful to the armourer who wishes to start down the path toward producing high-quality reproductions.

This book is divided into four sections. The first provides background and a kind of survey to place the work in perspective; the second and third outline specific tools and techniques required; and the fourth takes the armourer step-by-step through the creation of several 14th century projects. It is my hope that this book will be followed with more advanced texts detailing techniques and elements of design necessary to execute more difficult pieces, especially those of the "great period," the 15th century.

There are many schools of thought and many techniques that can be used to persuade a resilient piece of metal into shape. What I offer here is not meant in any sense to be the only way of approaching a problem within the armourer's craft, but I do hope it provides some ideas and suggestions that will help others both in their quest to improve their metalwork and to calibrate their eye. Along the way, the armourer has a unique opportunity to develop an art that can unlock the magic that transforms rough "fighters" into polished "knights."

Brian R. Price
Editor, *Chronique: The Journal of Chivalry*
Chancellor, The Company of Saint George
aka SCA Brion Thornbird ap Rhys, Earl, Knight, OL


Bascinet
Vervelles
Aventail
Visor (missing)
Spaulder
Cuirass
Gatlings
Rerebrace
Gauntlet
Couter
Wing
Vambrace
Lames
Fauld
Haubergeon
Cuff
Cuisse
Poleyn
Lames
Demi greave
Greave
Engraved Decor
Sabaton

SECTION ONE

THE ARMOURERS

Chapter

A Brief History of the Armourer and His Art

The armourer working in the European tradition can trace his lineage back through the whole of the Middle Ages, when the art flowered, through the Roman production houses and the elegant sculpted bronze armour of the Greeks, back into prehistory.

Throughout this time, the challenge for the armourer has always been to meet the threat posed by the weapons of the day, striving to maximize the protection of his harness while preserving as much mobility as possible. The problem for the Greek bronzesmiths was precisely the same as it was for the armourers of Milan or Augsburg, differing only in the tactical problems to be solved and the depth of their metallurgical knowledge. Both had to defend against hand and missile weapons, taking into account the tactics employed and the particular nature of weapons then in vogue to maximize the protection where it was needed most while preserving the soldier's ability to move.

Opposite page Figure 1.1 A 16 century harness by James Gillaspie, an American armourer from Flagstaff, Arizona. Owing to the increasing demand for armour by collectors and reenactors, skilled armourers are kept more than busy producing both single pieces and complete harnesses. This style dates from approximately 1550–1560 and was made for a collector.

EARLY ARMOUR

As long as man has fought, efforts to counter the devastation of weapons on the human body have been attempted. The earliest armours, probably animal hides,

were possibly reinforced with bone and wood. The first helmets were probably made of bone.[1]

Bronze—an easy to form yet easily hardenable alloy of copper, tin, and other trace elements—was an early material used in the manufacture of helmets and weapons, it being a formidable material for both offensive weaponry and defensive harness. With the rise of Greek civilization, the skill of the bronze worker was called upon to create a new, stunningly beautiful armour for the *hoplite*, a male citizen who outfitted himself at his own expense.[2] Because each piece was individually raised in sheet bronze, they were frightfully expensive; only the richest of the *polis*, the citizenry, could afford the honor of serving in the militia.

As the centralization and organization of Rome dominated the Mediterranean and much of Europe, the Roman techniques of manufacture influenced even the most traditional Goth, Hun, Briton, and Viking. Roman manufacture enabled large-scale foundries to produce sheets of iron in great quantity, while other technological advancements allowed them to create helmets through spinning them on a lathe, driven by water or animal power, rather than raising by hand.[3]

Utilitarianism drove Roman design. Body defenses were made from easy-to-create and -fit strips of bronze, and later iron, in the Roman armoured torso defense, the *lorica segmentata*. Mass-produced armour was needed to equip and field the huge armies that maintained Rome's control over its empire. With the production facilities and technologies employed, the armour proved up to the task—the superior plate defenses of the Roman army were an important advantage against the more lightly armoured opponents faced by the Empire over much of its life.

With the fall of Rome, the capacity to create large sheets of iron, along with the automated production techniques employed, was lost completely.[4] Owing to its ease of manufacture, the mail hauberk—used heavily by Roman cavalry and non-Roman legions—remained dominant in Europe until the 15th

Figure 1.2. Corinthian helmet from the Royal Armouries in Leeds. Greek, 7th century BC. (Photo © Board of Trustees of the Royal Armouries, IV.541.)

Figure 1.3 Created for reenactors, the Roman lorica segmentata above was made by Peter Fuller of Medieval Reproductions

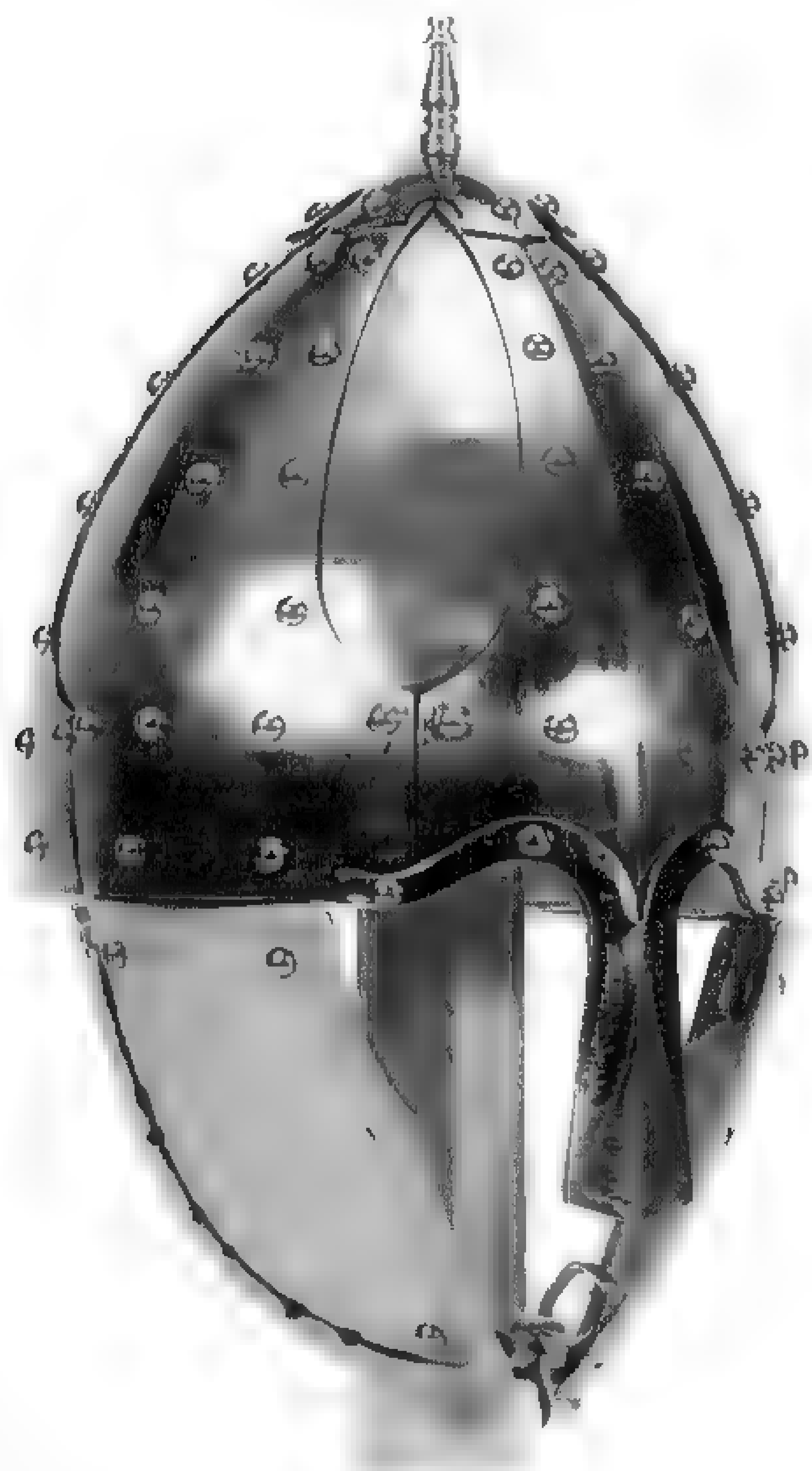


Figure 1 4 An early helmet by Peter Fuller of Medieval Reproductions. Note the persistent conical shape and the multiple-plate "spangen" construction

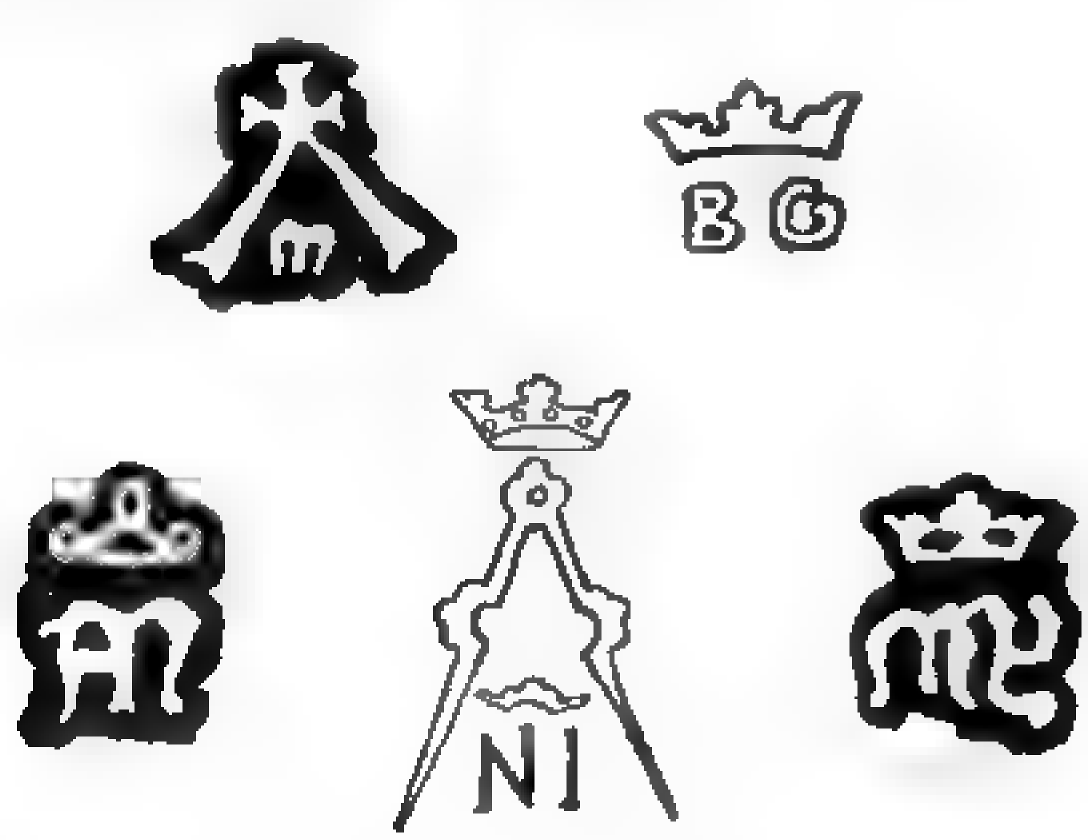


Figure 1 5. Various armourers' marks of the Milanese armourers

century. Because large sheets of iron needed to fabricate helmets from a single piece were no longer available, helmets were instead constructed using the "spangen" technique, where smaller plates were riveted together to form a helmet bowl. In shape the helmets retained the old conical form or were copies of the dimly recalled Roman designs. During this time bronze was sometimes substituted for the superior iron that had nearly superseded it, but the frequency of such substitution remains unstudied.

Armourers working in this period were probably local; I have as yet found no evidence for armour production centers before the 12th century. The large variance in local styles supports this thesis, and it was not until the 13th century that the armourers of northern Italy and Germany began an export trade throughout Europe. These two regions were to completely dominate the production of armour throughout Europe until the 16th century, notwithstanding small production centers in London, Bruges, and in various French cities.

THE ARMOURERS OF MILAN AND VENICE

By the 14th century, the finest armour in all of Europe came from the Italian houses. Late in the century, the Missiglian family of Milan became an exporter of fine armour. Known by reputation throughout Europe, passing the talents of their art from father to son in an increasingly vertically integrated enterprise, the Missiglians continued to provide the finest armours throughout the 14th and into the 15th century.

Milanese armour tends to be rounded in appearance, reflective of the new humanism that characterized the early Italian Renaissance. Formed from large plates, the Italian armourers generally provided defense for the body through the qualities of a single plate of iron as opposed to their German counterparts, who chose—at least during the 15th and 16th centuries—to create their harnesses from many smaller plates intricately connected through skillful articulations.

Figure 1.6 A Milanese bascinet of the late 14th century. Certainly Italian and closely related to the famous example remaining at Churburg, it is one of the few bascinets where the helmet and visor seem to match. Weight with aventail 15 pounds 11 ounces. Bequest of Sir Archibald Lyle, 1946, in memory of his sons Captain I.A. de H. Lyle, Black Watch, killed at Alamein, November 1942, and Major R.A. Lyle, Scottish Horse, killed at Normandy, June 1944. From the armoury at Schloss Churburg, acquired in 1924 for the Mackay Collection, sold Christie's, July 1939, lot 70. (Photo © Board of Trustees of the Royal Armouries, IV.470.)

Figure 1.7. A barbuta attributed to Jacobo detto Bichognola, c. 1470. Notice the evolution of the line from the earlier bascinet (fig. 1.6) and the remarkable similarity between the barbuta and the Corinthian helmets of Greece (fig. 1.2). During this time Italian artists were rediscovering their classical roots, and the effects were clearly visible in the development of the style of Italian armour. This helmet is much lighter than the bascinets of the previous century, weighing just 4 pounds, 10 ounces; the thickness of the bowl varies from .045 to .125 of an inch. (Photo courtesy of the Metropolitan Museum of Art. Gift of Mrs. George A. Douglass, in memory of her husband, 1960. MM 60.151.)

Figure 1.8. Armourers' marks of some of the famous German armourers.

The Missiglians built armour at both ends of the spectrum. They created fine quality, custom-crafted works for the richer nobles in Europe, but they also produced so-called "munitions" armours for the masses, components of which were produced in quantity and sold by the piece. They built a commercial empire from their trade in armour, having in their employ miners, iron founders, sheet makers, specialist "plattners" who hammered the plates into shape, polishers who manned polishing mills powered by water wheels, and finally sales agents who sold their goods throughout Europe.

By the middle of the 15th century, Milanese and Venetian armourers were employed for their expertise throughout Europe, serving in workshops both royal and common. They maintained their popularity even as the rounded Milanese lines were replaced with a more international, homogeneous style. The fine chased and repoussé work of the Italian Negroli family was on a par with those crafted by the prestigious German armourers serving in royal workshops. As long as armour was in production, the Italian armourers remained among the most prestigious in Europe.

THE GERMAN ARMOURERS

German armourers of the 14th century built their expertise alongside their Italian counterparts, producing bascinets of exceptionally high quality in terms of metallurgy, heat-treating technology, and function. Always working on a smaller scale than that managed by the commercially expert Italians, the German craftsmen built smaller workshops, each patronized by various members of the nobility.[5] During the 15th century the Germans excelled in their understanding of metallurgy and the techniques required to heat-treat and temper their work, and German steel was even exported to Italy for use on the finer Milanese and Venetian harnesses.

By the early 15th century, German families became competitive with their Italian counterparts, producing pieces with the characteristic so-called "Gothic" linearity

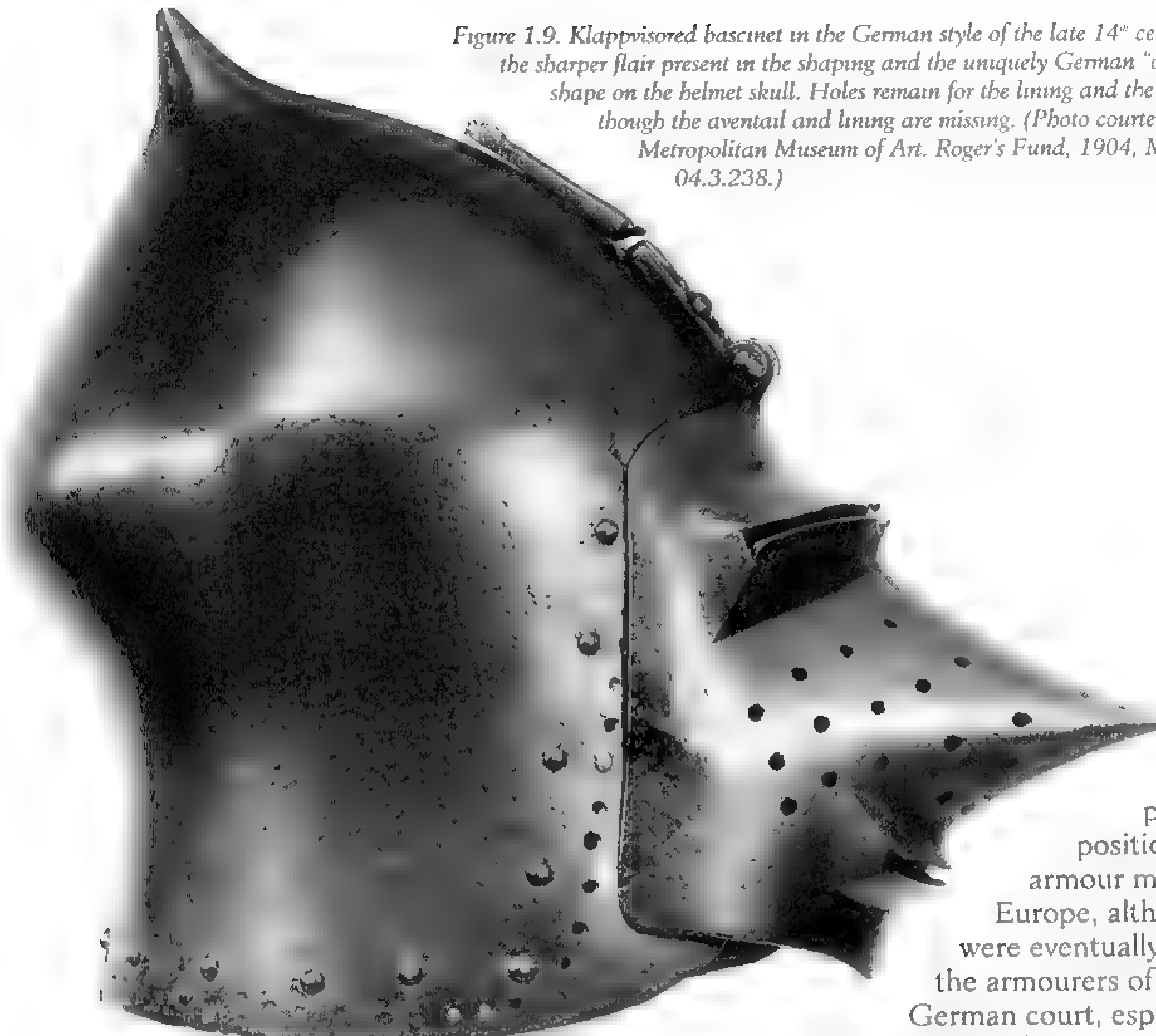


Figure 1.9. Klappvisored bascinet in the German style of the late 14^{th} century. Notice the sharper flair present in the shaping and the uniquely German "onion-top" shape on the helmet skull. Holes remain for the lining and the vervelles though the aventail and lining are missing. (Photo courtesy of the Metropolitan Museum of Art. Roger's Fund, 1904, MM 04.3.238.)

punctuated by sprays of reinforcing flutes. This style, led by the Helmschmid family, evolved throughout the century into the so-called "Maximilian" style of the early 16^{th} century. The German mastery of heat-treating and tempering techniques, combined with their use of the highest quality steels, enabled the German Gothic armourers to use narrower plates, a design element maintained into the next century.[6] A serious rivalry quickly developed between the two nationalities in terms of which armour was superior, but fine harnesses produced by the Missiglians and Helmschmid's can both be found in the richest armouries

During the 16^{th} century, the old German and Italian houses maintained their preeminent position in the armour market of Europe, although they were eventually joined by the armourers of the German court, especially under the patronage of the Emperor Maximilian.

OTHER CENTERS OF ARMOUR PRODUCTION

Most armourers worked on a much smaller scale than the large Italian and German houses. Local shops made copies of the pieces being released from Italy and Germany or repaired pieces damaged in the field. Traces of these lesser-known armourers are scattered throughout wardrobe account books,[7] and doubtless many of the less recognizable pieces found in museums came from small workshops in London, Bruges, and throughout Italy, France, and Germany. Technological advances in the design of armoured components continued apace during the 14^{th} and 15^{th}

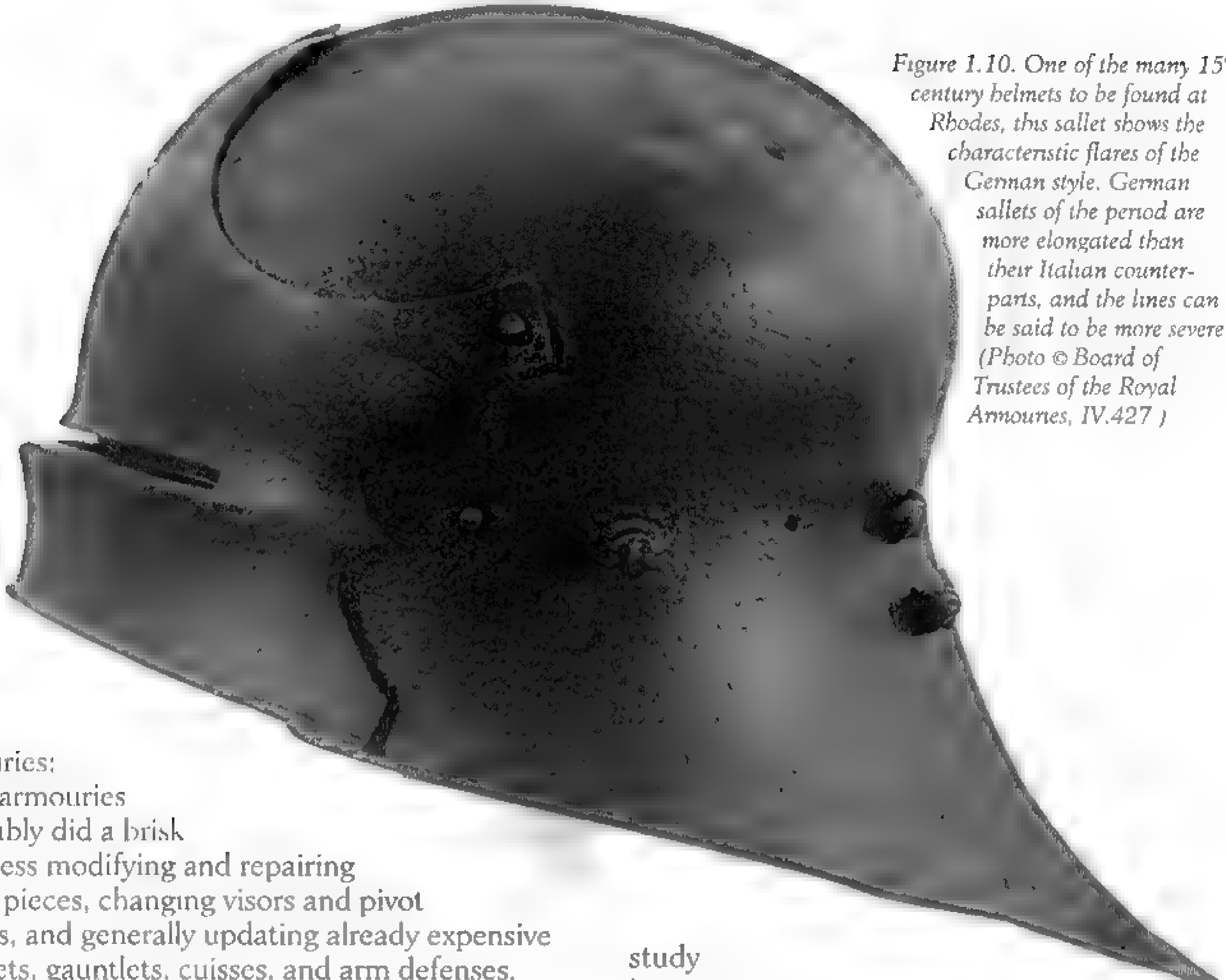


Figure 1.10. One of the many 15th century helmets to be found at Rhodes, this sallet shows the characteristic flares of the German style. German sallets of the period are more elongated than their Italian counterparts, and the lines can be said to be more severe (Photo © Board of Trustees of the Royal Armouries, IV.427)

centuries: local armouries probably did a brisk business modifying and repairing older pieces, changing visors and pivot points, and generally updating already expensive helmets, gauntlets, cuisses, and arm defenses.

Local armourers were probably also the source for mail and brigandine defenses. The skill required to make mail or coats of plate was notably less than what was required to forge plate defenses from iron, and the bulk of the soldiery was not equipped with the finer harnesses provided for princes. Little of this armour survives today.[8] Additionally, it is likely that during the 14th and 15th centuries particularly, armour of polymerized leather (*cuirboille*) or quilted cloth was heavily used for practice and in war, owing to the expense of armour forged from iron.[9] These pieces would not have survived to the present day, nor would they have been recorded in wills because they would have been of little value. Clothing, shoes, arming clothes, and similar items do not often appear, though I would expect to see payments to craftsmen in wardrobe and household accounts. Such a study has not yet been done.[10]

As early as the 13th century there are records of cuirboille being used in tournament combats,[11] though it is likely recorded in this instance owing to the unusual nature of its decoration, which accounts for the expense associated with it. Interestingly, this armour was to be used not by squires but by the king and his knights in a tournament fought *à plaisance* (for pleasure) with gilded clubs.

In the cities, armourers probably organized themselves into guilds, either on their own or together with other craftsmen working in mail, cloth, leather, or jewelry.[12] The London armourers of the 14th century left an ordinance giving the guild the right to inspect and check any imported armour, rejecting it should it fail to pass the standards set by the guild.[13] What

this amounted to was an early form of protectionism in the trade of arms, since only pieces that had been stamped with the local quality mark could be sold in the city.

Identifying pieces produced by smaller centers is exceptionally difficult, since many of the local armourers did not mark their work with distinctive stamps, and no registry recorded to whom the marks belonged. Doubtless many of the pieces that remain today were produced in small, local armouries, but identification and study of these workshops must await future scholars.

During the 16th century, Henry VIII, in a rivalry of chivalric prestige with Françis I and the Emperor Maximilian, established the Royal Workshops at Greenwich, seeded initially with armourers from Bruges and Italy but eventually staffed with German craftsmen. Under close supervision, this shop produced work that equaled the quality of the first-circle armourers in Germany and Milan. Some of the pieces made for Henry himself remain in the Royal Armouries at Leeds.

ARMOURERS AFTER THE 16th CENTURY

As gunpowder and combined arms tactics of standing armies dominated European military action, the role of the armourer changed. Most armour was produced in assembly line fashion, rough from the hammer. The armourer himself became more and more concerned with ordinance and guns.

At this point the traditional gap between munitions and princely armour grew wider than ever before. While mass-produced harnesses were being stockpiled in regional and national armouries,[14] exquisitely embellished armours decorated with etching, embossing, and elaborate gold washes were created with consummate skill. These armours were used chiefly at court and for parade, though some undoubtedly saw limited action. During this period, as in the 14th and 15th centuries, the decoration of the armour frequently was done by specialists in decoration rather than armourers, but the chased embellishment was done by the armourer himself. Today it is these armours that generally fetch the highest prices in the auction houses of Europe and New York. Some are so fine as to be considered national treasures.

It was not until the 19th century, with the Arts and Crafts movement, that the Gothic rediscoveries became popular and the armourer's craft once again found a market. Medieval harnesses, many of which had become dust collectors in the great houses of old families, were often sold at auction to neo-medievalists and arms collectors. The armourer was called upon once more to provide armour, this time not for use in the field but to fill out incomplete harnesses, repair damaged parts, and create new pieces in something approximating the medieval style for sale to collectors and decorators. Armourers working in this marketplace—then as now—had little opportunity to advance their name with their work, since the fact that a piece had been "restored" would quickly reduce its value. The most skilled armourers would thus find themselves in great

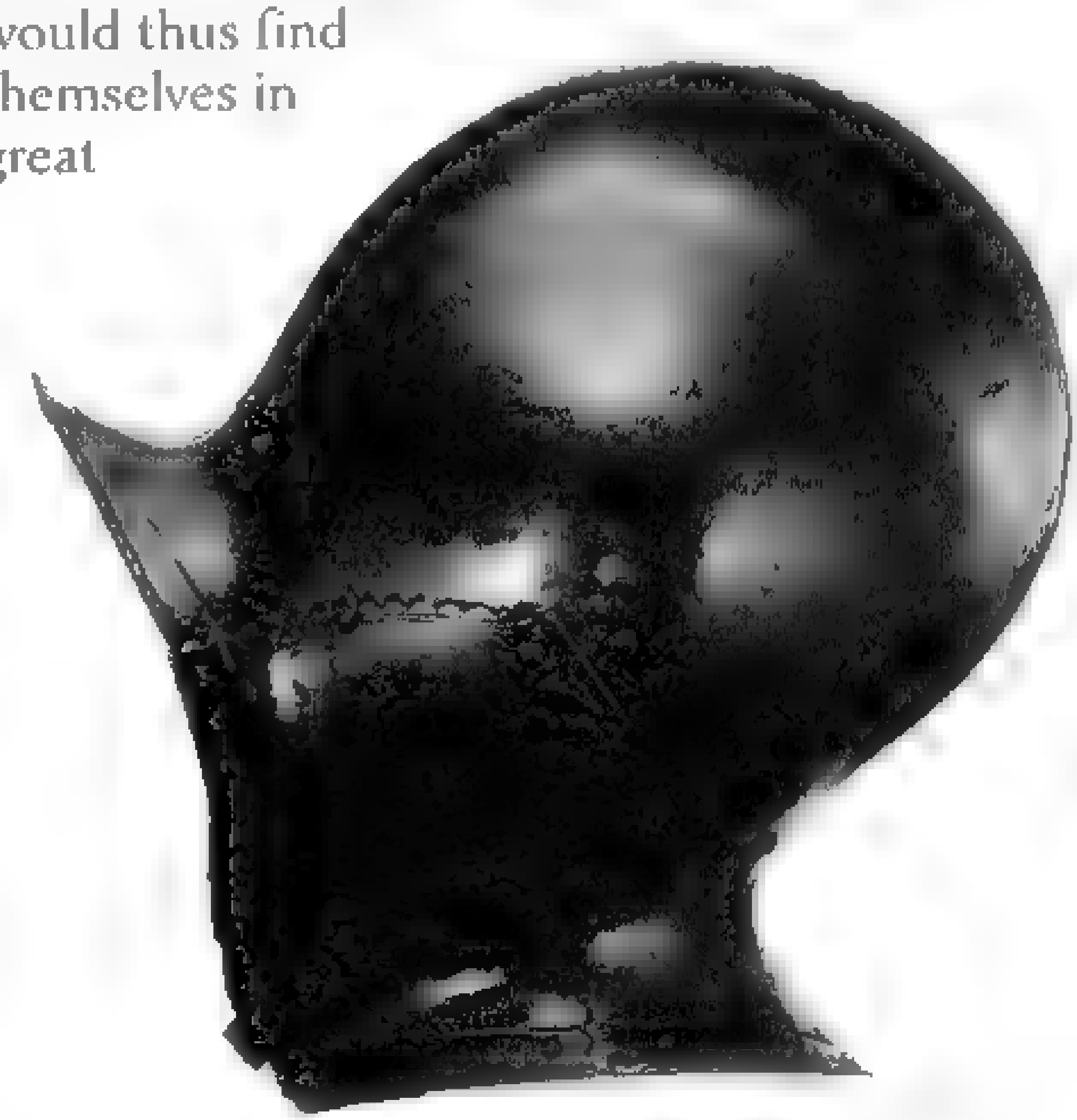


Figure 1 11. Manufactured in the fastest way possible this burgeonet dates from 1550–1560 but was left rough from the hammer. Such armour formed the vast majority of work performed as the 16th century gave way to the 17th, thousands upon thousands of nearly identical mass-produced pieces being collected at regional and national armouries. (Photo © Board of Trustees of the Royal Armouries, IV 523)

Figure 1.12. Helmet made for Philip II of Spain, c. 1550, by Desiderius Helmschmid of Augsburg. Desiderius did the embossing, while the goldsmith Jörg Sigman did the chasing and damascening. (Photo courtesy of the Metropolitan Museum of Art, Gift of William H. Riggs, 1913, MM 25.135.66.)

demand not by clients but by dealers and agents who were familiar with their work.

The same remained true into the 20th century as successive waves of popularity boosted sales of authentic pieces, reproductions, and forgeries. The great collectors —led by William Randolph Hearst— amassed great piles of armour at various levels of quality and repair, some doubtlessly produced as forgeries.

With the rise of the reenactment community since the 1960s, the armourer has found a new role, building reproduction and sporting equipment at varying degrees of accuracy and quality. Most armourers begin their careers making sporting equipment for reenactors. Some few of these seek to increase their quality sharply, either producing harnesses at a higher level of authenticity or branching out to serve the far more discriminating and restricted market represented by collectors. The recent renaissance in the study of medieval martial arts represents another nascent market. A few armourers have come to the craft through a formal study of arms and armour or medieval history, most of whom work with museums to maintain their collections.

At the end of the 20th century, the armourer has retained a small niche as a skilled craftsman, and there is now a renaissance of interest in the techniques of his trade. Modern techniques of metalworking may speed production, but as with the Arts and Crafts movement of the mid-19th century, there is a resurgence of interest in the magic wielded by the hand of a skilled craftsman. In the case of the armourer, the magic has the additional appeal of carrying the spark of the chivalric ideal, an ideal that continues to represent the very pinnacle of Western philosophy, like a familiar worry stone whose edges have been rounded through the ages but whose core has remained intact as the world has turned.

ENDNOTES

1 A helmet of boar's tusk, dating from 1400 B.C., exists at the Archeological Museum, Nauplia, Greece. Another far older helmet forged of solid gold for a rich nobleman in the ancient city of Ur can be seen at the Iraq Museum, Baghdad.

2 For a modern, thorough treatment of Greek equipment, see *Arms and Armour of the Greeks*, A.M. Snodgrass, Cornell University Press, 1967.

3 H.R. Robinson is generally held to be the preeminent scholar on military equipment of Imperial Rome. His landmark work *Armour of Imperial Rome* is a must-read for a student interested in this period.

4 Aitchison, Leslie. *A History of Metals*, p. 226. "During the two hundred years after A.D. 450, the only form of iron smelting that continued was strictly on a back yard scale." MacDonald & Evans, London, 1960.

5 Pfaffenbichler, *Medieval Craftsmen: Armourers*, p. 33–34.

6 Theodore Monnich, "Iron and Steel in the Making of Armour," *Chronique: The Journal of Chivalry*, #13, 1996.

7 Wardrobe accounts, close rolls, and wills form an important corpus of research material that can shed light on where knights of the period purchased their equipment. I have made extensive use of the *Black Prince's Register* (4 vols., HMSO, 1933) to support this thesis. Payments to the armourers of Edward III

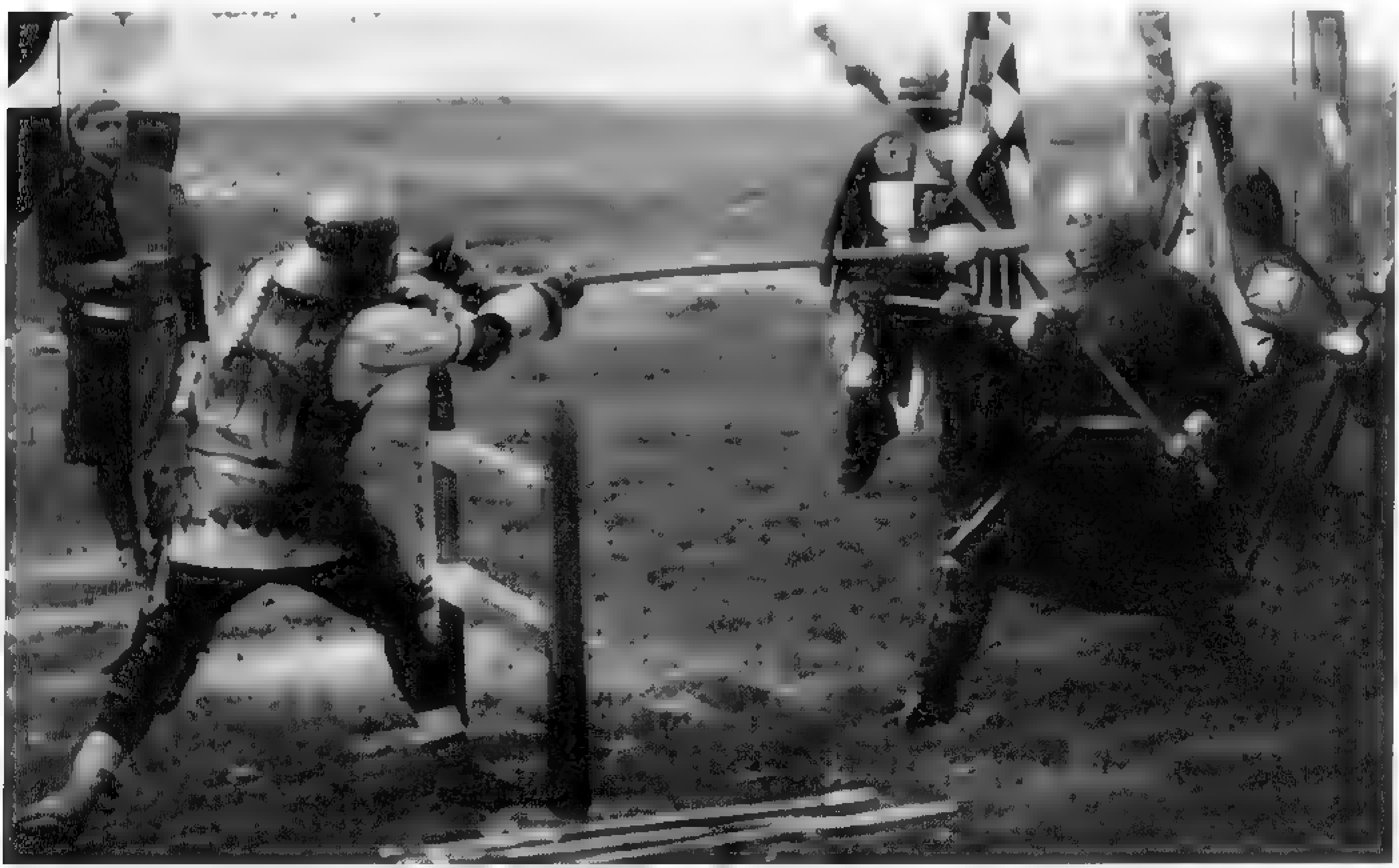


Figure 1.13. Armour for the béhourd by various armourers, c. 1992–1994. Today's armourers serve a variety of clients, from highly demanding collectors to tournament reenactors whose interest is both in authenticity and in the improvement of character through the chivalric models.

and the Black Prince appear throughout the financial records Similar though less well-studied documents exist for a host of knights in England and presumably in France as well. Additionally, Mr. Christopher Dobson has studied the contents of a 15th century armourer's will from Florence that details the armourer's possessions and his accounts, a study that should see publication in the near future.

8 Armour from the mass grave at Wisby is a notable exception Begnt Thordeman, *Armour from the Battle of Wisby* 2 vols , 1939

9 The amount paid for armour during the 14th century varies wildly Given the high variance in quality, plus transportation and middle man costs and domestic tariffs, it is difficult to arrive at something resembling "average" costs.

10 The most useful treatment for cuirboille remains John W Waterer's *Leather and the Warrior*, Museum of Leathercraft, Northampton, 1966.

11 Edward I ordered armour of cuirboille that was enhanced with silver and gold leaf, he also ordered silvered batons for this Round Table béhourd. "Copy of a roll of purchases for a tournament at Windsor Park in the sixth year of Edward I" Ed. S. Lysons, *Archeologia*, first series XVII (1814), 302–305

12 Pfaffenbichler, *Medieval Craftsmen*. Armourers p. 29.

13 City of London Letter Book F, fol. cxlii Reprinted in Charles Ffoulkes, *The Armourer and His Craft*, Methen & Co , 1912, p 171

14 See especially the armoury at Gratz, Austria, where thousands of mass-produced harnesses of the period have been stored since the 16th century

Chapter 2

Armour Reproductions:

Armouring for Collectors and Museums

Today, armourers around the world work in traditional medieval style. Some of these efforts are striking in both their historical accuracy and their artistic magic, while others are more workmanlike, addressing the functional requirements of tournament as sport. Most balance somewhere in between, trying to run a business while extending their ability as craftsmen. All of these armourers have clients interested in their work based on a general resurgence of interest in the Middle Ages and in the idea of knighthood.

What we have today is an extension of the medieval cult of chivalry, an amalgamation of ideas rooted in the history of the medieval period enhanced by romantic iterations of medieval myths. As has been the tradition of chivalric literature since the Middle Ages, the core components of the chivalric ideals have been updated over time to meet the realities of each new age, sculpting the ideas to meet the needs of the time. The popular culture of today has once more embraced something of the pastoral medieval fantasy, perhaps as an escape or possibly a kind of cultural longing for the mythical order and romance of medieval life.

To meet the various demands for this interest in the Middle Ages, modern armourers work a spectrum of

Opposite page Figure 2.1 Reproduction armour — such as this full Milanese harness produced by Brian Price and Luke Apker — helps reenactors explore the whys and wherefores of how armour was constructed and used in the field.

niches. At one end, companies mass-produce armour for purely decorative purposes. Reproduction armourers strive for authenticity in appearance and construction, working with collectors and museums who require exacting copies and extrapolations. Restoration armourers also work for collectors and museums, creating seamless repairs and restoring missing plates to existing medieval pieces. Reenactment armourers work across the spectrum, balancing requirements of their sport with various degrees of authenticity. Each of these broad niches has subniches within it; armourers who specialize in a particular period or regional style. Many armourers exist simultaneously in more than one, building armour for more than one market, gradually expanding their skills by creating pieces for clients with diverse interests in terms of the level of authenticity required.

Some modern armourers train apprentices and students, transmitting their knowledge and building their businesses while creating stylistic schools, passing on their accumulated knowledge for the first time in nearly 300 years, a new Renaissance in the understanding of the armourer's technique.

COLLECTORS, ARMOUR, AND THE NOBILITY

The knight's prowess, his strength of body and spirit, was the foundation upon which his role as a nobleman was laid. His armour provided the physical manifestation of political legitimacy, communicating his strength in arms as political power. As far back as ancient Greece, the right to bear arms had been associated in Western culture as a function of the nobility. Greek hoplites, Roman generals, German chieftains, Carolingian paladins, Medieval knights, the Renaissance or Restoration gentleman, the modern officer—the list goes on.

It is this connection between arms and nobility that drives collectors. As the social station of knighthood began to fail during the 14th and 15th centuries, rich members of the middle classes began to purchase the

Figure 2.2. The armour of Ernst Schmidt was sold throughout the world, originally as decorator armour. Though Schmidt was able to capture the "gist" of the Gothic style in this example, significant differences mark it as a copy. The same usually applies for all but the finest armour created today, and though this detracts from their value, the magic of the original still echoes in the final product.

trappings of nobility in order to gain social prestige. This included titles, heraldic devices, estates, and even complete harnesses. Gentlemen longing for a connection to the traditional aristocratic way of life collected bits of armour, some of the wealthy building great collections in partial imitation of the original old families that had maintained armouries since the Middle Ages. Many of the great armouries of the world—the Metropolitan Museum in New York, the Wallace and Victoria and Albert Collections in London, the Kienbusch Collection in Philadelphia, to name just a few—were built around the collections of rich industrialists who then bequeathed them to museums.

During the 19th century, the arts and crafts movement looked to an idealization of the Middle Ages for relief from the horrors of industrialization. The quality of fine-wrought handwork and craftsmanship became an important thread in the artistic culture of the day, and this in turn provided a renaissance of traditional techniques in art. This, combined with a strong market for authentic armour from the medieval period, drove a variety of craftsmen to produce copies and forgeries designed for sale at auction or through antique dealers. Some were originally sold aboveboard as copies—as with Ernst Schmidt's thriving business—while others were less ethical and peddled their forgeries as originals.

Figure 2.3. A fine Maximilian helmet recently available on the market from Peter Finer, a London antiques dealer with an exceptional reputation. Offered for sale at $20,000. A good reproduction done with composite welding techniques might run $2,000, while one done in the correct style could cost as much as $4,000 to $5,000

Today, some of these forgeries are still sold as originals, especially through less knowledgeable or less scrupulous dealers, because the market for authentic armour is still strong. Collectors flock to Christie's, Sotheby's, arms fairs, and a host of antique dealers in London, Berlin, and Paris. The larger houses – especially those mentioned above—are well served by an ethical curatorial staff, so purchasing from them is relatively safe, if expensive. Most armour still available dates from the late 16th or 17th centuries, so reproduction armourers are kept busy making copies of pieces from the 14th, 15th, and early 16th centuries. Would-be collectors should choose carefully, buying from reputable dealers to reduce their chances of acquiring a forgery. For pieces that are not available on the open market, good quality

reproductions can be purchased from some of the better armourers. And these have the advantage of being custom fit to the client.

DECORATOR HARNESSES

The vast majority of these 19th century reproduction pieces do not function properly—eyeslots improperly placed, helmets and joints that don't function, lames sometimes riveted in place. Modern decorator armours, produced by the thousands in Spain and Mexico, are an extreme example of this, purely symbolic pieces designed to stand in the corner, embellished with etching but incorrect in most every aspect. But they do fulfill a function, and the market for them continues to thrive.

Decorator armourers are generally business concerns first and foremost, competing by price with other, similar firms. They sell primarily through dealers, though some also merchant their goods at Renaissance Fairs or through catalog sales. In 1999 dollars, a full suit of decorator armour ran between $750 and $3,000.

REPRODUCTION AND RESTORATION ARMOURERS

Collectors want pieces that are as exacting as possible in their line, detail, and construction techniques. Budget is generally a key factor for reproduction clientele; most will not be able to afford the additional time required to create a piece using the correct medieval techniques. Added to this, medieval armourers did not document their techniques, so in many cases the corpus of information available to practicing armourers is restricted to a few photographs in a museum catalog Modern armourers must experiment with different techniques derived from the work of the silversmith and blacksmith, extrapolating from existing examples, manuscript illuminations, and memorial brasses and collaborating with other armourers to improve the authenticity and quality of their creations.

Most reproduction armourers use modern techniques like those presented in this book to

Figure 2.4. A commercially made modern suit of armour. The piece is not so much medieval as "medievalesque"—the joints are not functional and the harness cannot be worn—but the whole of the surface is etched to make it more interesting Such harnesses are available from many dealers; the one above retails for $2,200

strive for an authentic appearance without the expense associated with the original techniques. Many of the better reproduction armourers started armouring for reenactors, where they sharpened their skills in preparation for making the more exacting copies required by high-end collectors.

By definition, most of the pieces required are 14th, 15th, and early 16th century examples, since these pieces are nearly impossible to find on the open market. Simple transitional, Italian export, and rough German Gothic pieces are both compelling to the collector and within reach for the intermediate armourer, so an aspiring artist will find a ready market for his work. By the time an armourer is ready to improve his quality, he has probably found an affinity for armour of a particular period and style, not too different from the armourers of history.

Figure 2.5. Recently, some armour, mail, and thin steel copies have been commercially produced in India. The example above represents a 15th century Venetian barbute, but it is made from exceptionally thin steel and is welded. These pieces are widely available in the United States; the helmet above retails for approximately $179 from Museum Replicas

As the intermediate reenactor or reproduction armourer progresses, there usually is an increasing interest in authentic technique. Alongside the technical ability, there must be a continual refinement of the eye coupled with an increasing artistic maturity. These skills allow the armourer to create whole new pieces comprised of elements of style native to the period. This "new" piece should be correct for the intended period, a recreation that "could have been" medieval.

As the skills increase, the quality of the reproductions increases as well; more is captured than just the lines and engineering of the historical pieces. This artistic growth gives the artist-armourer the ability to do more with his craft than simply copy; instead he can communicate what he understands of the chivalric ideal and of the character of his client. As a painter works with pigment and a sculptor with stone, so the finest armourers work with iron and steel.

The key technique to making the transition from "intermediate" to "master" is raising—the ability to create pieces without resorting to welding. Using the correct technique yields a result closer to the medieval original. The best reproduction armourers can produce pieces for museums and the most finicky collectors. A select few armourers have extended their skill such that they are capable of restoring medieval pieces, making fakes (I have personally seen several high-quality fakes, done by armourers whose work is unfamiliar to me, sold as medieval originals), or creating original artworks of the very highest quality.

Restoration armourers frequently disappear into the collector market, their abilities tapped to repair damaged pieces. Collectors and dealers don't necessarily have an interest in advertising the fact that restorations have been made, so the restorer's work is generally not so well known as is the work done by those who reproduce harnesses for general sale.

Some armourers have come not from a reenactment but from a scholastic or craft background. Their interest in the armour often stems not from the chivalric romance that drives the reenactment societies, nor

Figure 2.6. This exquisite reproduction by Wade Allen demonstrates many fine features of the armourer's art being rediscovered by modern craftsmen. Note especially the fine articulation on the bevor, the details of catch and latch, the crest, and fine roping.

from the collector's impulse, but from a technical or artistic interest in the armour itself. Some of these armourers become scholars, working as museum curators or in academia and researching various aspects of the armourer's art.

PRACTICAL CONSIDERATIONS

To armour for collectors, the reproduction armourer should strive to achieve as accurate an interpretation of the required armour as possible. This means that over time he should work to improve the line of the armour made by his hand. He should improve the quality and accuracy of the engineering, fitting plates closely, crafting smoothly functioning joints and pivots. Pieces should be well finished, with edges carefully filed and sanded smoothly. The inside should be finished as well, painted to guard against rust, or tinned. Strapping and padding should be as authentic as possible.

Broadly speaking, the armourer can work within an historical period in two ways. The first is to copy an existing piece, striving toward perfection in terms of duplicating the original. This is an excellent test of the armourer's skill, educating him as to the probable techniques used historically while also refining his eye. Alternatively, he can attempt to create a new interpretation using stylistic elements correct for the context of the period. This is hard to do well, but it offers more flexibility.

An aspiring armourer can also use multiple-piece construction to create a harness element, provided that the quality of the resulting exterior line is superior. It is easier, really, to capture the medieval line by using the correct technique, but this involves advanced hammerwork that requires some time to master. It is easier to strive *toward* the line, building technique and creating pieces at a lower cost. These pieces should develop the armourer's skill so that he can begin to make the transition to correct materials and techniques. Over time, the armourer may well grow to mastery, bringing the magic of the medieval armourer to life and enchanting those who view his art.

ENDNOTES

1 Price, Brian. "Contemporary Chivalry: The Internet and Modern Tournament Societies." Delivered at the Popular Culture Conference, 1998.

Figure 3-1. Historical medieval reenactors strive to create a moment in time as precisely as possible. The tournament societies of the 14th century, featuring armour like the man above taken from the Trebon Altarpiece, celebrated knightly prowess and the other chivalric virtues on a colorful, competitive stage. Modern tournament societies strive to do the same thing.

Chapter

Armouring for Reenactors:

Tournament Societies and Medieval Feats of Arms

One of the problems in studying armour from the 14th and 15th centuries is that very little of it remains. There are many unanswered questions about how the armour functioned and how it was created that cannot be answered purely through research alone. What kind of garments were worn under the armour? How was the legharness worn? How much of the armour must be worked hot, and what should be done cold? Why were visors attached in such-and-such a manner?

Reenactors are serving as unaffiliated reconstructional archeologists, discovering the answers to some of these questions, providing a laboratory for the observation of different configurations of armour, and experimenting with different fabrication techniques and field deployments. Although the reenactment communities vary widely in the accuracy of their creations, they provide a variety of circumstances under which the armour is tested.

Reenactors work to recreate various aspects of medieval society, working in the traditions both of history and romance. *Historical* reenactors provide a valuable microcosm in which to observe reconstructed details of medieval life, all interacting to create a more coherent picture of what life was like during a particular place in time. *Living history* reenactors work more in the

tradition of the chivalric romance, where feats of arms serve as a mechanism for the improvement of the individual as defined by the chivalric ideals. In both cases, the armourer has a role to play, providing important elements of the medieval framework that make the reenactments work for their intended purpose.

Armourers who are working with historical reenactors should pursue their craft as reproduction armourers, striving for great accuracy in terms of line and construction technique, researching their work as much as possible and delivering pieces that offer no distraction from the goal, which is to create as authentic a picture as possible. Combat in these groups is generally less stressful on equipment than is true with the competitive living history societies. This lack of competition adds few constraints to the design of the armour—historical accuracy is far more important in this context than is true within the living history societies.

Armourers working with living history societies have a different and unique role, however, since their work is frequently used as defensive equipment for the various combat arts practiced within their organizations. The rules for these arts have a substantial impact on the construction techniques and designs used as well as the usefulness of historical armour of different periods selected for that style of combat. These groups use the tournament not as a setting for a purely historical reenactment but in a very medieval way, as a stage upon which their chivalric participants strive to demonstrate and improve their knightly qualities.[1]

Medieval tournaments permeated knightly life, both in the ideal and in history. First devised to train knights for war, refining the techniques required to maintain a cohesive charge with couched lances, it gradually became something more, a celebration of knighthood's strength.[2] Tournaments have always been an activity through which knightly renown is earned, a proving ground for both virtue and skill while simultaneously entertaining for the gallery who watches the action.

Modern tournaments strive for these same objectives, building a tone of medieval idealism

Figure 3.2. The encampment of the Klauwerts group of Belgium, a reenactment group dedicated to recreating military camp life of the 15th century.

Figure 3.3. Early encounters within the SCA, the largest of the living history societies. Over time, both the equipment and the technique used in this organization have evolved considerably

Figure 3 4. Although the SCA allows for an extreme range of equipment so long as it adheres to the safety standards, some combatants go to great lengths to fight competitively while simultaneously striving for ever-improving accuracy in terms of their field accoutrement

Figure 3 5 Both the martial skills required for competitive fighting and the quality of equipment for reenactors within the SCA have improved markedly over the years, though there is still much room for improvement

that can impel knightly conduct from the combatants.[3] Magic is created in a well-run feat of arms, an interesting mix of competition tempered by the combatants' sense of honor and mutual respect. This respect often transcends the individual living history organizations, binding the combatants together in very much the same way that knights of various nationalities were bound by an international bond of chivalric fraternity. They celebrate the chivalric ideals as interpreted by modern reenactors, building on the medieval realities viewed through modern lenses—a rediscovery of the Western martial arts.

Broadly speaking, there are two families of reenactment. The first kind uses rebated steel weapons, either in choreographed or slowly executed combat. The second features full-contact and full-speed combat that emulates the tradition of the medieval *béhourd*, a tournament form fought with wooden weapons.

COMBATS A LA BÉHOURD

As the largest and oldest of the living history groups, the history of the Society for Creative Anachronism (SCA) is representative. In 1966, a group of fantasy/science-fiction aficionados hosted a party themed as a "medieval" tournament. A success, the group quickly grew.[4] Based in the tradition of medieval romance, the ideals were loosely cast into a medieval "society" centered around competitive tournaments and recreating a whole spectrum of medieval arts. By 1980 there were 13 regional "kingdoms," each with its own king, peerage, and population. Taken together, the SCA claimed more than 40,000 participants.[5] (The SCA is not, however, the only game in town. There are several other large béhourd-based societies, most notably Markland, Ltd., based on the American East Coast.)

Within the SCA, each kingdom has a parallel social hierarchy structured around a king and queen. Arguably, the core of the kingdom resides around the knights, skilled combatants recognized for their prowess and

character. The knights share their status with the "laurels" (granted for accomplishment in the arts) and the "pelicans" (granted for service). The king, the victor of a special "crown" tournament held two or three times per year, leads the kingdom with his consort, supported by a core of administrative officers.

Although the SCA allows a myriad of historical periods, knights within the society hold a special place, the exemplars who are expected to demonstrate and exercise the chivalric virtues by their conduct both on and off the field. They comprise approximately 5 percent of the combatants within the SCA, but they also hold a majority of the expertise in terms of martial prowess, at least in tournament combat. In wars, where mass counts more than individual skills, the knights serve as heavy cavalry by virtue of their experience and expertise rather than by virtue of armour and a horse.

Fighting within the SCA is unique in the whole world of the martial arts. It is fought on foot with wooden weapons that are close in weight and performance to medieval broadswords. Because the combat is full speed and full contact, the armour takes a beating, providing the last line of defense for the particularly critical target areas of the head, body, and leading thigh.[6]

More than 30 years old, the martial art of SCA fighting has progressed rapidly, hard-fought as combatants vie against one another for victory in the larger double-elimination tournaments. This tournament form itself is modern rather than medieval, but it has served to emphasize the speed and strength elements of the style.[7]

Like other groups, SCA fights are conducted under the auspices of rules that regulate equipment, target zones, conduct, and field conditions. Some of these rules—such as those concerning thrusting and legal target zones—have a substantial impact on the forms of combat that follow. Most combatants take to the tournament field with sword and shield; the shield is very effective since blows below the knees are disallowed. Other combatants fight with wooden representations of polearms, axes, maces, spears, and longswords. Each form has subtle skills associated with it, making for very interesting encounters when fought between skilled combatants.

Although not based on historical research, SCA combat is in the tradition of the medieval béhourd, a form of tournament fought with clubs. Fought *à plaisance* (for pleasure) in Western Europe from the 14th and 15th century, béhourds were designed to test both virtue and prowess.[8] Medieval béhourds, fought with whalebone or ash weapons, probably allowed armour for war (in iron or steel) or for practice (in cloth or cuirboille). SCA fighting is very

Figure 3 6. The author's sword and shield used for reenacting pas d'armes and in SCA tournaments. The shield features a raised charge of molded fiberglass, modeled after the medieval technique of molding shields in "gesso durro." The sword is rattan but is fixed to a permanent metal hilt crafted by the author. The weight on both is comparable to medieval originals—the sword is 2 3/4 pounds and the shield 4 pounds 5 ounces

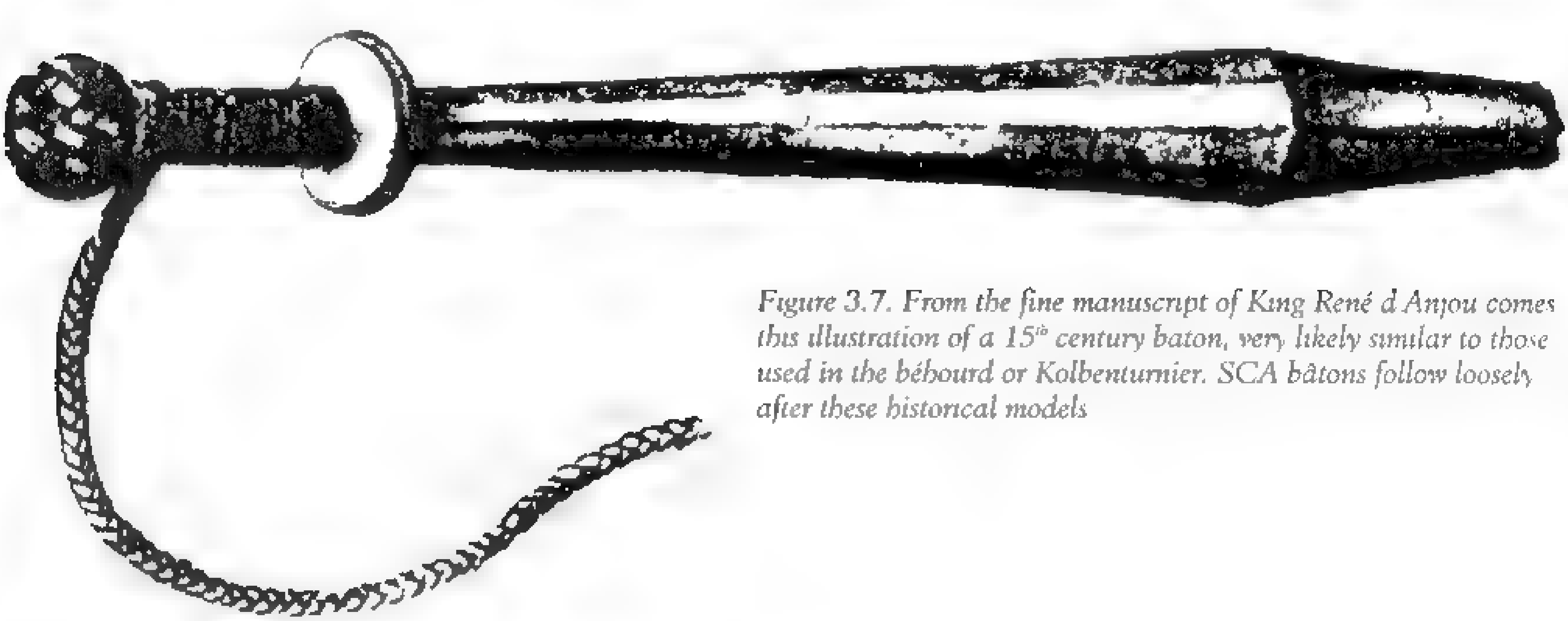


Figure 3.7. From the fine manuscript of King René d Anjou comes this illustration of a 15th century baton, very likely similar to those used in the béhourd or Kolbenturnier. SCA bâtons follow loosely after these historical models

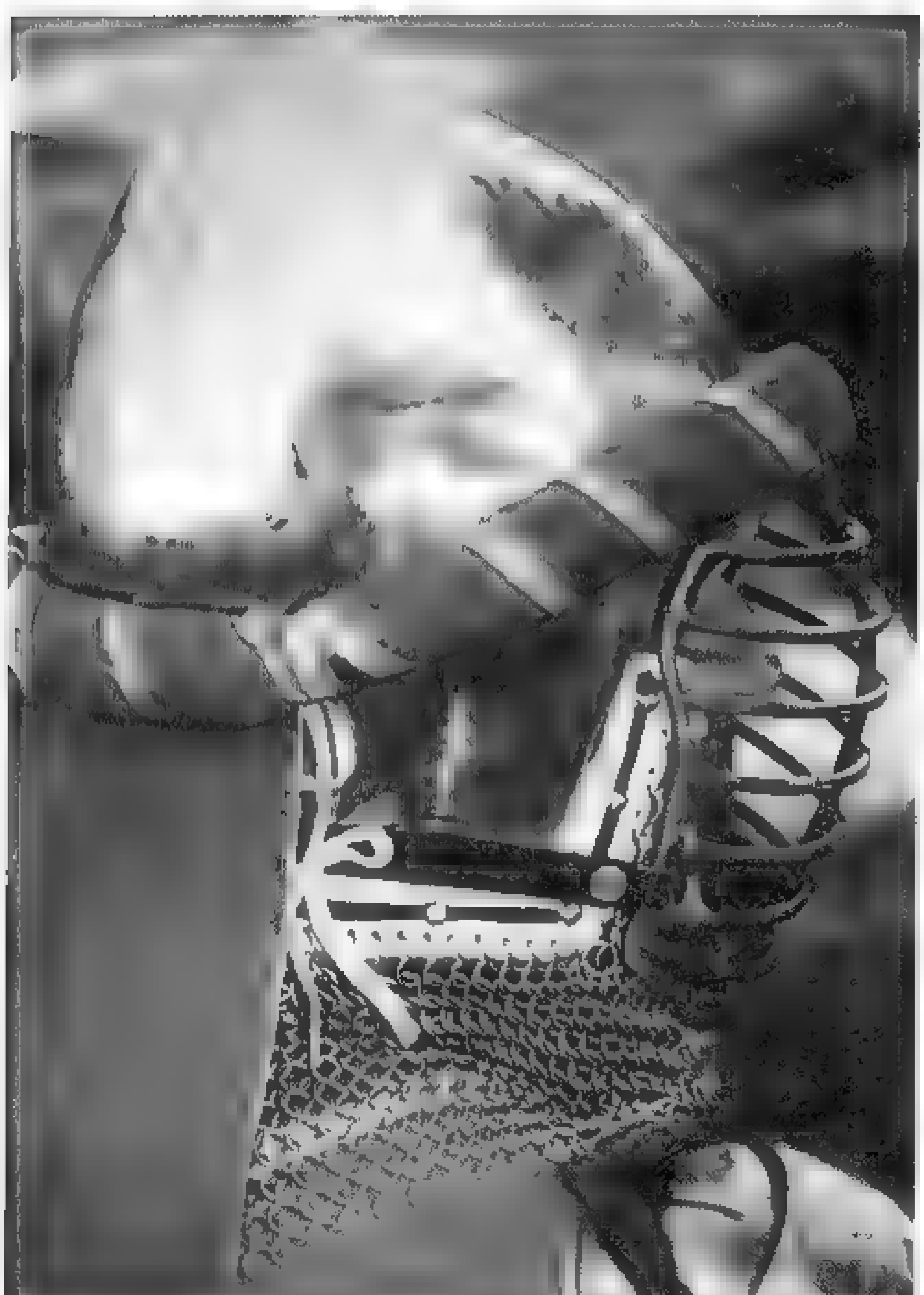


Figure 3 8. Through the use of the equipment, béhourd reenactors experiment and make new discoveries about how medieval armourers and combatants approached a knight's harness. Armourer James Earley's grilled tournament bascinet helps to create the chivalric tone that accompanies martial tournaments in living history societies

similar, testing the abilities of both combatants in an atmosphere that expects chivalric behavior from all combatants, regardless of rank or stature.[9]

To emphasize this goal, SCA fights are conducted without judges (there are safety officers, called "marshals"). Instead, the combatants' responsibility lies within them, a kind of regulated honor system guiding the acceptance of blows. Their conduct under these conditions, combined with their skill, builds their reputation, the most important component of social status within the SCA. It is this quality, combined with the loose affiliation with historical reenactment, that separates the martial arts as practiced within the SCA from other, more traditional arts such as fencing or one of the Eastern arts.

Alongside the single combats mentioned above, the SCA practices group combats referred to as "mêlées." Combatants organize themselves into units based on regional or household affiliation, striving to work together both within the unit and between units to achieve a victory: sometimes a single battle, sometimes a collection of battles counted as a "war." Archery is starting to play a larger role in SCA wars, as is siege-weapon engineering. Horses are precluded by expense and regulation, since they present an extreme safety hazard and are legally protected against use that exposes the animal to harm.

Above: Figure 3 9. The largest engagement of all medieval reenactment groups, the SCA mêlées evoke something of original battles in their massive size, competitive atmosphere, unit cohesion and swirling confusion. Some battles have topped more than 2,000 combatants

Right Figure 3 10 Within tournament societies such as the Company of Saint George (USA), béhourd combatants are conducted in the pas d'armes style of the 14th and 15th centuries The companies approach fighting within the SCA with a heightened sense of authenticity and in the chivalric ideals as expressed in medieval literature of the period

The largest SCA battles pose as many as 2,000 combatants, a swirling simulacrum of a large medieval tourney or battle. Even without horses, the intensity of the struggle catches the imagination of nearly everyone present, combatant and spectator alike.

Despite the fact that the SCA centers around combat, it would be wrong to neglect the myriad of other arts, crafts, and activities sheltered under the SCA umbrella. Every conceivable medieval art and craft is represented by artisans at different levels of ability, while the social fabric of the organization is as complex and dynamic as the medieval original.

As the preeminent umbrella organization in terms of size, the SCA is exceptionally tolerant with regards to authenticity, a home at once for the highly accurate and the highly irregular. Vikings can be seen side by side with 12^{th} century Moslems, who might be drinking with 15^{th} century Burgundians and Musketeers. Though this weakens the SCA as an historical entity, it provides a unique strength borne of diversity that has spawned many smaller, more focused efforts at reenactment, providing the common rules and social framework that allow many of these niche reenactors to thrive where they might otherwise perish for lack of interested new recruits.

TOURNAMENT COMPANIES

Founded as a reaction against the utilitarian "sport" ethic and equipment adopted purely to provide a competitive advantage within SCA tournaments, specialized companies of knights, squires, and ladies have infused a new interest in the High Middle Ages to the larger SCA community, advocating both improved authenticity and conduct based upon the ideal chivalric virtues as documented in medieval treatises. For the most part, the tournament societies follow the model established by the Company of Saint George

Figure 3.11 Brent Junkins, experienced knight and talented armourer, readies himself for combat in a Company of Saint George pas d'armes. Another combatant, Manfred von Haalstren, from the Company of Saint Michael, also stands resplendent in his tourney harness.

(USA), founded in 1990.[10] Based on the German tournament societies of the 14th century with elements from the monarchical orders such as the Spanish Order of the Band or the English Order of the Garter, tournament societies generally operate under a charter governing their members for the purposes of improving their conduct, prowess, and quality of equipment.

Tournament societies have strongly embraced the spirit of the medieval romance, holding béhourds in the form of round tables, pas d'armes, and the tournaments of William Marshal.[11] Roundtable discussions of chivalric conduct parallel similar discussions required of the medieval Order of the Star, opening the dialogue between combatants to discuss what is expected of the ideal knight and lady.

Because most of the romantic literature and tournament forms appropriate to the tournament society philosophy comes from the 14th and 15th centuries, most of the tournament groups have narrowed the allowed band of equipment to this time, sometimes to within a decade or so of the 14th century. As such, it is possible to find something of the historical reenactment wedded to the martial art of the living history groups, a unique blend that is rising in popularity.

STEEL COMBAT GROUPS

Paralleling the growth of the béhourd-based romance societies, a variety of living history groups practice their combat not with wooden weapons but with rebated steel swords. Generally speaking, the combat practiced by these groups are either choreographed according to remaining *fechtbuchs* (fighting books) or conducted very slowly to avoid injury.

The quality of their authenticity varies widely (as it does within the SCA), and most of them share a similar organizational structure patterned on the SCA or Markland originals. The larger groups have an organizational structure that is remarkably similar to the one established by the SCA, while the smaller groups tend to be more like historical reenactment societies, incorporating combat as part of their effort to recreate "a day in the life of" a medieval person.

From a martial standpoint, the combats held by live steel groups are completely different from the full-contact fighting done within the SCA. Most societies have adopted the SCA/Markland model, where a form of honor system is used, regulated by the mechanism of renown, while others have judged systems.

Some groups, such as the Adrian Empire or the Empire of Chivalry and Steel, actually practice a form of combat not dissimilar from that done by the SCA, saving that the combat is conducted not with rattan or wood but with rebated steel swords. I have had little direct experience with these groups since I saw them around the time of their founding in 1987, but they have flourished in the interim.

Both have social structures based on affiliated memberships in households, political power being exercised in a "parliament" comprised of households, baronies, and other components. The Crown is determined in a "war" where contenders for the crown build their armies as they may and then conduct a large engagement—usually including arts competitions—to determine the victor.

Knighthoods within both societies are granted in recognition of field prowess and chivalric conduct, though knightly titles are also earned through arts or service. Both social structures clearly show the influence of the early SCA, though they have long since evolved in a slightly different direction.

Both Adria and the Empire practice their combat using various classes of weapons. Oriental *shinai* (bamboo fencing practice swords) are used at the lowest level, enabling all to participate with a very low barrier to entry. Renaissance bladework is practiced using the new schlager blades now commercially available. Armoured or "hard suit" combats are offered but are strictly regulated.

In both societies, dull steel weapons are used with full harness. Blows to the knee and below are disallowed, as are blows to the groin, neck, and hand. The weapons used are heat-

treated swords, poleaxes, and others with edges usually 1/8 inch wide. Tips are rounded, and thrusting is prohibited in both cases.

Blows are thrown at half or quarter force, with varying degrees of speed. Elegance and efficient delivery are emphasized, and blow-calling is done on the honor system similar to that practiced within the SCA. Combatants act out blows taken to the leg or arm, "dying" when accepting a legal blow to the head, neck, or torso. The result is fighting that is very similar in tone to what is done within the SCA, saving only for the speed and full-force components.

Steel combat societies tend to have rigid rules concerning armoured defense for the head, hands, and limbs. Each group has a specific, written set of rules that combatants must adhere to, so armour intended for use in these groups must conform to these standards. The armourer is strongly encouraged to obtain a copy before working on pieces intended for an unfamiliar form of combat.

In Europe and Australia, there are many small groups that practice various forms of live steel combat. Most are similar to the models described above, but several use the *Regia Angellorum* combat standard. In this standard, blows are always thrown to one of five regions, and a set of parries is also taught.[12] Competitive fighting with live steel is the intended result, where full-speed blows are pulled. Good conduct is the desired goal. I have come across several groups in Australia and England that use this standard.

Normally the armour worn by live steel groups is as authentic as possible within the price range of the combatants themselves. Although the weapons are often dull rather than sharp, serious injury is a possibility if a combatant fails to defend himself or if a component of his harness fails.

A Word on Waivers and Legal Protection

All combat societies have written waivers whose intention is to clearly demonstrate preknowledge of the sport's danger and to reduce the exposure of the official organization and the membership from lawsuits resulting from injuries incurred as a result. This legal protection does not likely extend to product liability for equipment supplied by armourers, tailors, and others, so an armourer working in conjunction with these groups would be well-advised to seek out legal assistance to determine their exposure and possible defenses.

OTHER PRACTITIONERS OF MEDIEVAL SWORDSMANSHIP

Besides the reenactment societies, which devise various social hierarchies around their practice of Western sword arts, there are other, more focused attempts to refine the practice of historical swordplay.

Central to the function of these groups is study and deconstruction of the remaining fighting handbooks of the Middle Ages and Renaissance, termed *fechtbuchs*.[13] HACA, the Historical Armed Combat Association, is the largest of these groups, a loose affiliation of well-organized practitioners of the medieval and Renaissance sword arts. AEMMA, the Academy of European Medieval Martial Arts, is another active force in this community; based in Toronto, Canada, it has worldwide reach.[14]

Most of the martial arts groups, following the lead of HACA, study medieval swordsmanship using a variety of techniques designed to address shortcomings in the most common methods. Following the HACA method, padded weapons are used for "full contact" work and for sparring by novices with a minimal investment in armour. Combat with wooden "wasters" is next on the ladder of techniques employed, and for this kind of sparring rudimentary helmets (in AEMMA, a chapel-de-fer as constructed in Chapter 30 is the minimum) or fencing masks are required. Fingered gauntlets, while not required, are ideal for this kind of work (see Chapter 33).

Many of the historical swordplay practitioners are moving toward working with complete cap à pied harness, but the high cost has forestalled widespread practice of armoured—as opposed to unarmoured or semiarmoured—work. In order for these groups to achieve their objective of working to

recreate armoured combat (AEMMA's specialty), modern armourers will have to produce much more functional harnesses that take medieval heat-treating (and thus weight) into account. At the middle tier, there is a need for much improved munitions equipment to address novice and intermediate combatants. This armour must be reasonably standardized to reduce the cost while at the same time advancing the martial arts groups beyond sporting equipment and into authentic armour.

From the armourer's perspective, combat with rebated weapons presents some unique challenges. Not only must a full cap à pied armour be available for practice (which means greaves, something that is a rarity amongst groups that don't use full-leg targeting) but the armour itself will take more damage from the rebated weapons than it does from bâtons or wasters, so the patrons must be prepared for this. Heat-treated armour will certainly help.

Some martial arts groups such as AEMMA have been successfully experimenting with a reinforced mail standard. Helmets in this case can be from the 13th century (barrel helmets being relatively inexpensive and butted mail shirts easy to come by). It is unlikely that any forthcoming movements will adopt the mail over padding as a standard in the near future, which means that the armourers will be producing armour from the 13th and 14th centuries rather than from the 15th, which will reduce the cost and thus lower the barrier to entry.

The infusion of techniques from this burgeoning "fechtbuch" community promises to pay great dividends for the reenactment and armouring communities. More plate armour will be required, which will create new markets and thus encourage young armourers to produce more. Experimentation will full-leg targeting will likewise create a demand for greaves, too often overlooked. The study of medieval technique will also improve the combat as practiced in various combat societies, while the chivalric philosophy that binds these groups together will provide the philosophy missing from the Western martial arts.

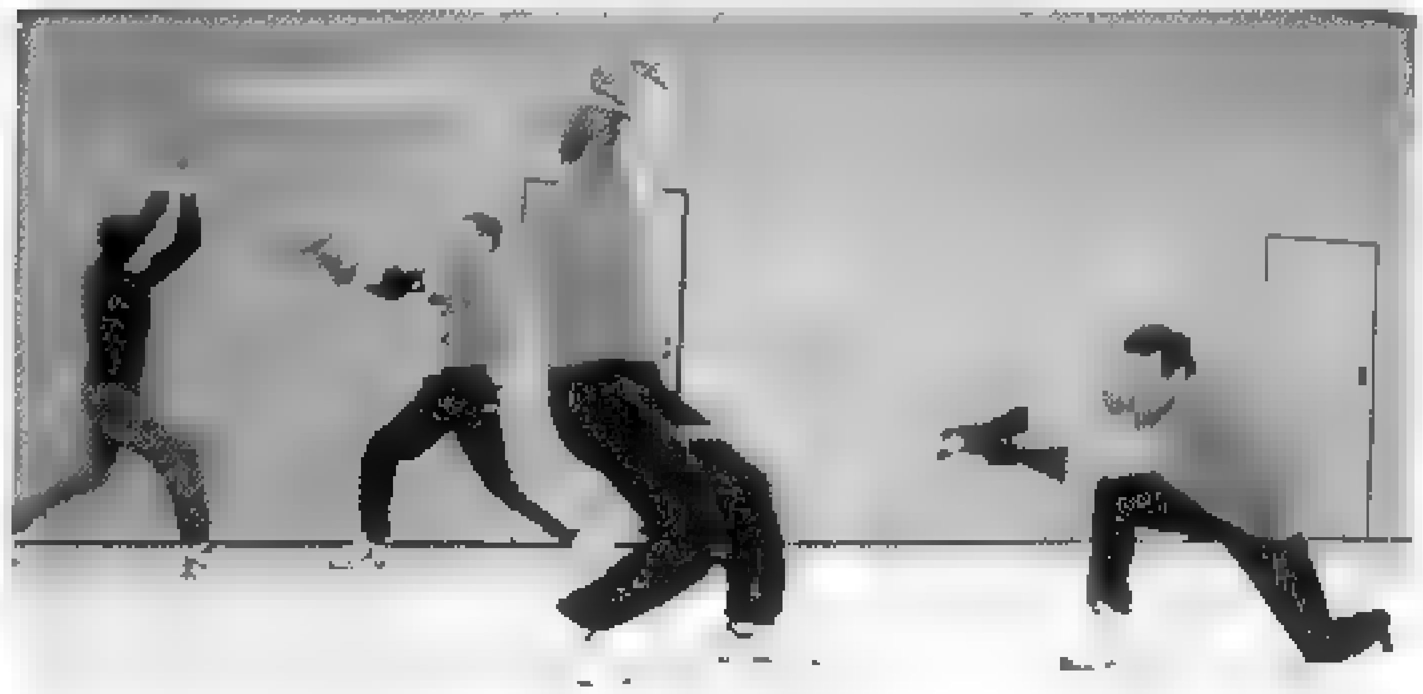


Figure 3.12. HACA and other similar groups practice swordsmanship from a strictly martial perspective, working to rejuvenate swordsmanship as a Western martial art.

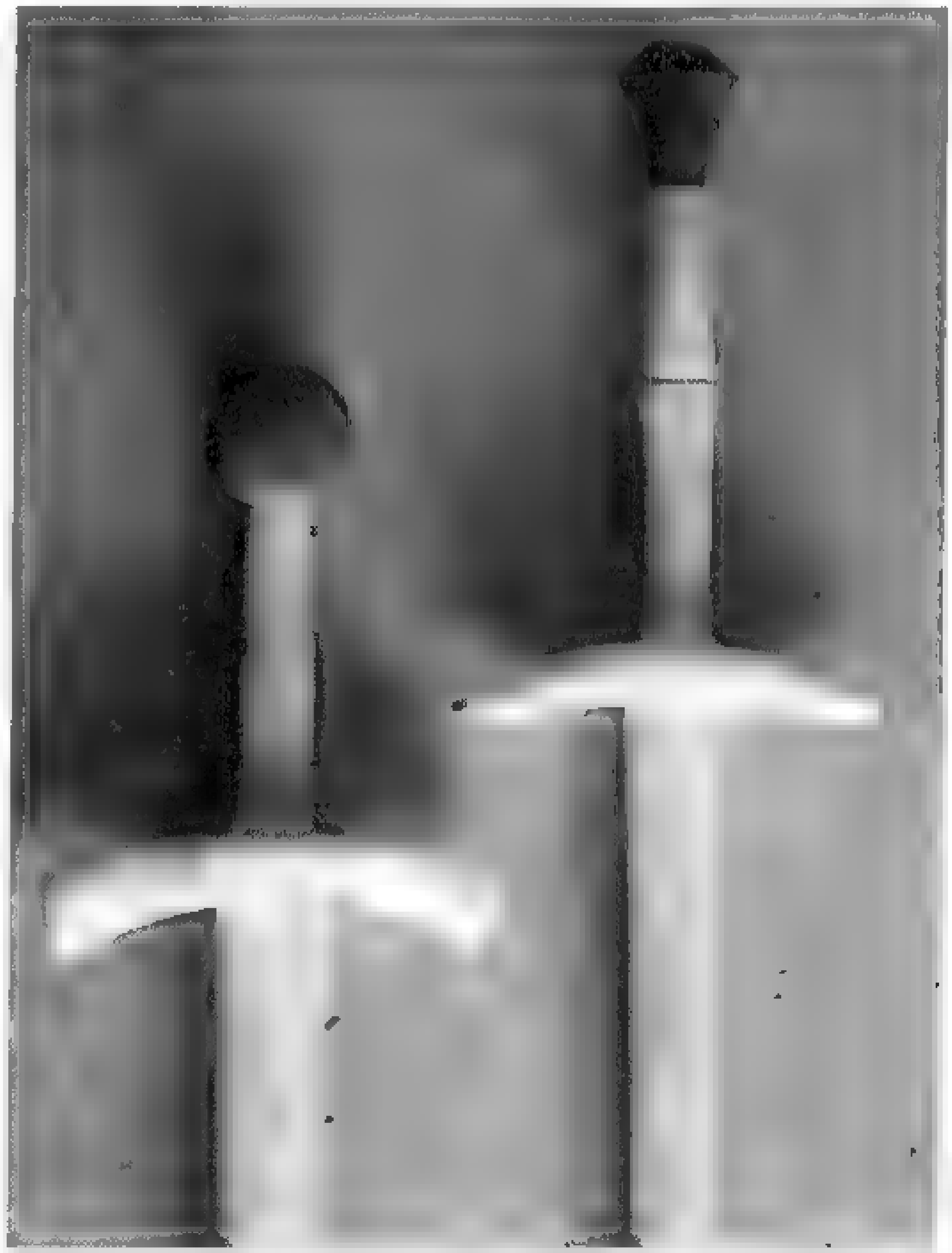


Figure 3.13. HACA and AEMMA members practice with a variety of padded and wooden weapons. The wooden "wasters" above are not used with armour, however; HACA students practice full contact sparring with padded weapons and limited armour.

Figure 3.14 Not all living history revolves around tournament reenactments. There are reenactment groups for virtually every medieval period. In this photograph, Steve Moffett, a California armourer (center), participates in a 16th century German reenactment.

Figure 3.15. Some modern combat rule systems, like those of the SCA, create odd situations that would have been unfamiliar to a medieval armourer. Here an SCA combatant kneels after receiving a "good" blow to the leg. Only infrequently does original medieval armour allow for such movement because it was largely unnecessary.

CONSIDERATIONS IN ARMING REENACTORS

When crafting armour for reenactors, it is possible that precisely accurate reproductions will prove difficult to use in the combat form practiced by the client. The usual reason is that the combat practiced by the reenactor differs significantly from the styles done when the armour was in fashion. Barring unusual experiments that survived because they proved useless on the field or were for parade, the armour produced in the Middle Ages worked well, balancing defense against the weapons faced with the mobility of the man wearing it.

Within the SCA, Adria, and the Empire, for example, combatants typically must fight from their knees to account for a stout blow taken somewhere on the thigh or back of the leg. This necessitates that the leg armour bend to accommodate fighting from a kneeling position, something uncommon at best during the Middle Ages. Although most original legharnesses did not allow the knight to lean back while kneeling, modifications to the polyen, the associated lames, and the back of the greave are often necessary when making legharnesses intended for SCA combat. Likewise, many reenactment groups feature rules that govern maximum openings on occularia, grilles, and even on some "basket-hilt" defenses for the hand.

Gauntlet cuffs present a special difficulty. When wielding gauntlets of a medieval design, reenactment patrons commonly complain about the apparent lack of freedom in the cuff that defends the wrist. They find medieval designs far too restrictive, and yet medieval gauntlets changed little in this respect for nearly 200 years. Why? Because the style of combat practiced by the reenactor's medieval predecessors differs substantially from that which is practiced today.

Medieval combat was largely, though certainly not exclusively, fought from horseback. On horseback, the swordsman need not move as efficiently as a footman because he is assisted in his blows by the mass of the horse multiplied by the rate of movement, all focused

into the edge or point of the weapon by the knight through the use of reasonably simple movements. These movements—which the author has tried on horseback—yield substantially greater force than is generated on foot even with the most efficient blow delivery. As a result, medieval knights did not need to "break their wrist" as modern combatants feel they must, and thus gauntlet cuffs were not flared to allow it. Such flaring would have added a zone of risk because a widely flared region would have been exposed to the fine edges and points of sharp weapons. For the medieval knight, therefore, the design of the gauntlet was perfectly functional; it had been tested starting with the earliest experiments in the 14th century and remained more or less static in terms of wrist mobility until the end of the 16th.

The rules governing the combat must be taken into account when considering creation of a piece for reenactment work. The challenge is to create a new piece that both satisfies the rules and consists of the stylistic elements of the desired time period.

PRACTICAL CONSIDERATIONS

Armouring for reenactors is in some ways much more demanding than is producing armour for collectors. The techniques of construction are often less important than the outcome, but the resulting component must at once meet aesthetic and functional expectations, defending the combatant as he practices his art while simultaneously being as accurate a reproduction as possible. The best armourers serve both ends, encouraging their clients to adopt homogeneous, authentic defenses that will perform well in their intended role.

Authenticity

Since very few of the larger societies have a strong sense of historical accuracy, and owing to the legal climate, there is a tendency to mandate modern standards rather than to look for historical solutions. Closed-cell foam padding is often required for use in helmets, for example, whereas horsehair, tightly stuffed into the helmet lining, is effective and authentic. Woolen blankets at the knees functioned in place of the modern knee pad, and a well-made arming coat or gambeson provided the requisite padding needed at the elbow. Medieval knights and combatants faced the same concerns in terms of defense requirements that modern combatants face, and the armourer can make the reenactment considerably more effective if he researches and advocates appropriate medieval solutions.

Clients—especially novice or intermediate combatants—rarely know much about the historical period they are working in. Left to their own, they might well opt for a Norman casque (because of the visibility afforded) affixed with a grille, a 14th century brigandine, and 15th century leg defenses of uncertain origin. The armourer should know better and should attempt to offer the information the client needs to become more knowledgeable in presenting his field appearance.

Safety

The first concern an armourer should have for his client is one of safety. What is the intended use to which the armour will be put, and what kind of armour best suits the client's purpose? What are the rules governing this type of defense, and what sort of stresses will the component be subjected to? An armourer who practices swordsmanship will have a distinct advantage in answering these questions, erring on the side of safety when design decisions arise.

Maintenance

Armour used for practice of a martial art, as well as for tournaments and group encounters, will take a beating. The armour must be hard or heavy enough to withstand many blows over time. The facilities available to care for the armour might also be a concern, since high polishes must be maintained either by hand or with a polishing setup.

ENDNOTES

1 Keen, Maurice, *Chivalry*. Yale, 1984. Dr. Keen provides a fine summary of his sentiment: ". . . we shall encounter also, in connection with the

tournament in particular, evidence of a very strong streak of caste consciousness, and more generally of a concern to bring the decor of the sport more in line with the literary models, together with what appears to be a love of the gesture for gesture's sake "

2 Keen, Maurice, *Chivalry*. Yale, 1984. A specific reference is included on page 212, although this remains a potent thesis throughout the work: "Like the orders of chivalry, the tournament and the pas d'armes, with all their glamour and ceremony and partly by means of it, could be used to remind the knightly world of the serious social and ethical responsibilities that the code of chivalry imposed."

3 Barker, Juliet. *The Tournament in England*. Boydell, 1986, p. 86. "One of the most fruitful sources of inspiration for hastiludes was chivalric romance literature, though it was their stories, settings, and ideologies rather than the bloodiness of their combats that was imitated." See also my other book, *Pas d Armes and Roundtables: Re-enacting Medieval Feats of Arms*, Chivalry Bookshelf, 1999. The whole book is an exposition on this concept, with instructions for holding a successful encounter.

4 Oral history from Frederick of Holland. Personal discussion with the author

5 Andrew Smith, conversation based on paid registrations

6 *The Marshall s Handbook*, 1999 edition, SCA Publications

7 That the SCA style of combat moved in this direction, a bulk of the credit goes to Paul Porter, aka Duke Sir Paul of Bellatrix, who over a course of more than 30 years worked through the mechanics of the combat style, bringing years of Eastern martial experience to the young art. As a result, the refinement of the form owes a great deal to Mr. Porter and a handful of other skilled teachers who successfully communicated their passion to receptive students, who then had the opportunity to practice their art in SCA tournaments

8 Barker, Juliet, *The Tournament in England 1100–1400*. Boydell, 1986, pp. 148–149.

9 Price, Brian, *The Book of the Tournament*, Chivalry Bookshelf, 1996, pp. 3-7. See also the official SCA Rules of the List (Rule # 5), "ALL combatants shall behave in a knightly and chivalrous manner at all times." (Emphasis mine.)

10 The charter for the Company of Saint George is found in Appendix A, and it maintains a permanent Web address at http://www.chronique.com/. Note that there is another company by the same name—a reenactment society that does a stunning job of recreating 15th century camp life in Europe. The two groups have no formal affiliation and different goals but seem to share a passion for the High Middle Ages.

11 "William Marshal" tournaments attempt to capture something of the more free-form and less pageantry-laced tournaments popular in the 12th and 13 centuries. Combatants organize into small groups for the purposes of capturing members of other groups, fighting in mêlée style over the course of a whole day. Although done on foot rather than on horseback they are generally very well-received by the combatants, even those who don't appreciate the chivalric stage of the pas d'armes

12 Regia Anglorum Standards for Training, 1997

13 Increasingly, fechtbuchs—fighting manuals left by medieval fencing masters—are becoming more accessible to practitioners of Western swordsmanship. Notable titles include Talhoffer's *Fechtbuch* (1443, 47 and 67 editions), Fiore dei Liberi's *Flos Duellatorum* (Italian manuscript of the 14th century), the I.33 (anonymous 13th century fechtbuch now in the Royal Armouries), and *Jeu de la Hache* (15th century manual on polearm work)

14 HACA maintains a permanent Web presence at http://www.thehaca.com. AEMMA's Web site is at http://www.aemma.org.

Chapter

The Modern Armourers

Historically, the armourer's craft has been largely undocumented, shrouded in secrecy by the fierce pride and competition of a very narrow specialty. No medieval armourer has written anything yet discovered concerning technique, and modern scholars have had great trouble piecing together clues about how armourers functioned from wills, deeds, wardrobe accounts, and other records.[1]

Amongst the modern armourers there is less of a barrier. The vast proliferation of reenactment groups, knowledgeable scholars, and continued interest in armour by collectors has inspired numerous high-quality books on the subject. Examples of this trend are the overview by David Edge and John Miles Paddock[2] and the *Churburg* reprint with companion volume by Mario Scalini. The book on the metallurgy of the Greenwich Armouries by Dr. Alan Williams is another such work.[3] The high level of scholarship in these books has provided something of a base for modern students, and it is indeed a welcome infusion of new material.

Today's armourers are more drawn to their craft owing to a passion for the art and "voice" of their work. In the relatively casteless social systems of today, many can choose their profession rather than being forced

Opposite page
Figure 4.1. Very likely the finest armourer in the United States, Mr. Robert MacPherson produces harness both for collectors and a select group of tournament reenactors. This 16th century garniture has been etched on the borders and these same borders washed in gold

into it because of a family obligation. The armourers of today practice because they love their art.

Despite a friendly climate for the sharing of information, barriers to communication and sharing of technique do exist. These barriers are based more on affiliations and personality conflicts than on competitive drive. A certain amount of competition does exist, but it is relatively low key.

At the high end, demand for the art is not easy to satisfy. The finest armourers have waiting lists of years, while the quality at the other end of the spectrum is sometimes depressingly low. Because there is no easy answer to the question, "Where can I learn to make armour?" few who have the interest can find suitable ways to get started, and only a small percentage progress to real mastery.

For those who begin with scholarship, training is indeed hard to find. Generally, a study of metallurgical requirements and silversmithing and blacksmithing technique will yield some practical insights, while a study of art, historical records, and, most importantly, authentic examples retained by the major museums conveys a sense of historical context often not well understood by the reenactors. Handling of authentic pieces lends a distinct advantage, as details of construction do not have to be divined from photographs alone or copied from modern interpretations. It is a long path, however, and not an easy one to follow.

Within the reenactment communities, many of the finer armourers take on students or informal apprentices, teaching them the techniques and their interpretation of medieval design. Some of these reenactment armourers rise in quality to serve the collector or museum, but most create sporting equipment with various degrees of authenticity. Many of the finest leave the art for more lucrative opportunities.

The purpose of this book is to reduce the barrier faced by novice and intermediate armourers in their pursuit of the armourer's art.

Figure 4.2 Like their medieval counterparts, modern armourers hallmark their work as a statement of pride and for considerations of artistic renown. Clockwise from the upper left, Brian Price; Robert Valentine (Valentine Armouries); Peter Fuller (Medieval Reproductions); Tom Hugeunin (All Saints); Robert MacPherson (Maestro Roberto di Milano); Greg Anderson, Brent Junkins (Anshelm Arms).

In this chapter the armourer will find an introduction to some of today's finest craftsmen and their work. Hopefully the gallery that follows will provide inspiration for modern students, and in future years many more pieces can be added as sculptures in steel by the aspirants of today.

REENACTOR ARMOURERS

Without question, the bulk of the world's modern armourers are active within the various reenactment communities discussed in Chapter 3. Most reenactment armourers are led by a primary "master" working with several students or apprentices. Other reenactors frequently come into the workshop to build a piece or two, helping out with other projects in exchange for teaching, materials, and assistance with the difficult steps.

Figure 4 3. Black harness from the 14th century by Brent Junkins

Learning their craft almost entirely through trial and error or under a more experienced armourer, the work produced in these workshops tends to be derivative of the "school" represented. These modern schools are informal lineages of armourers who share stylistic preferences based on where they learned their craft or who provided the most influential examples.

Because reenactor armourers learn their craft on the job without the scholarly base enjoyed by the museum community, they have an unfortunate tendency to copy work of other reenactors rather than conduct sufficient research. This, combined with the irregular rule sets of reenactment societies, sometimes produces truly odd interpretations of armour that are more medievalesque than medieval.

Against this weakness, the armourers themselves are often combatants who use their product under the stress of combat. Their clients are often highly dedicated martial artists who practice swordsmanship and other medieval feats of arms, and this produces data from the field that the armourer can use to improve his ability to analyze puzzling elements of medieval design. Their pieces must function under the stress of a competitive martial art, one that shares many common elements to the arts as practiced during the Middle Ages. This experimentation serves as a separate kind of knowledge base, one that in the ideal case would be married with the scholastic expertise of the reproduction armourers.

During the 1970s, a small group of combatants and artisans took an interest in the history and construction of arms and armour. It can be said with confidence that Brian Flax led this movement forward, driving a flurry of experimentation and practical research. Mr. Flax's passion helped other armourers to get started, pushing them in the direction of more

authentic design. Indeed his occasional journal *The Hammer* flourished for many years. It is still in print today, bound into "best of" volumes that still provide something of a base for armourers in many romantic societies.[5]

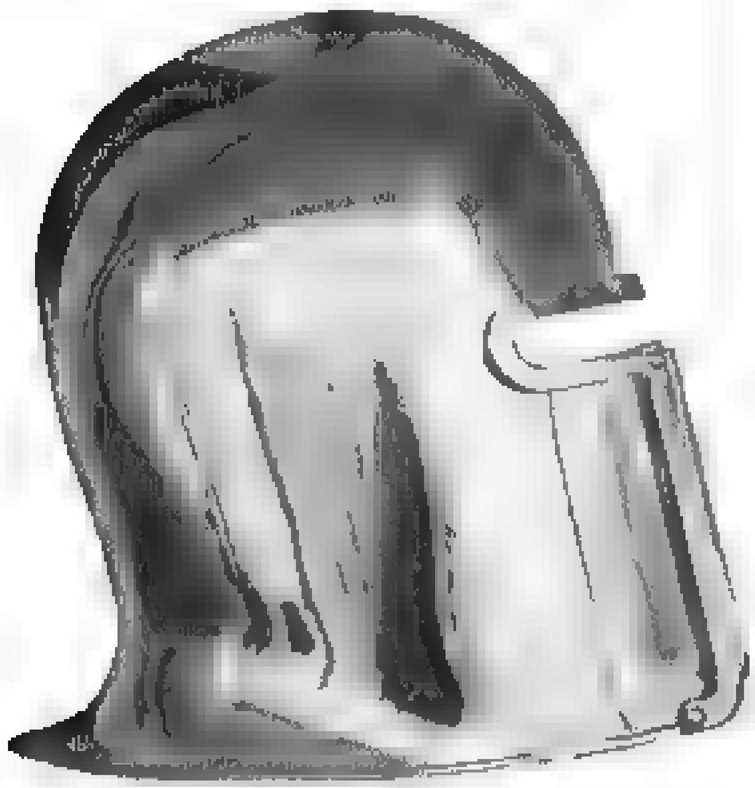
The Valerius School

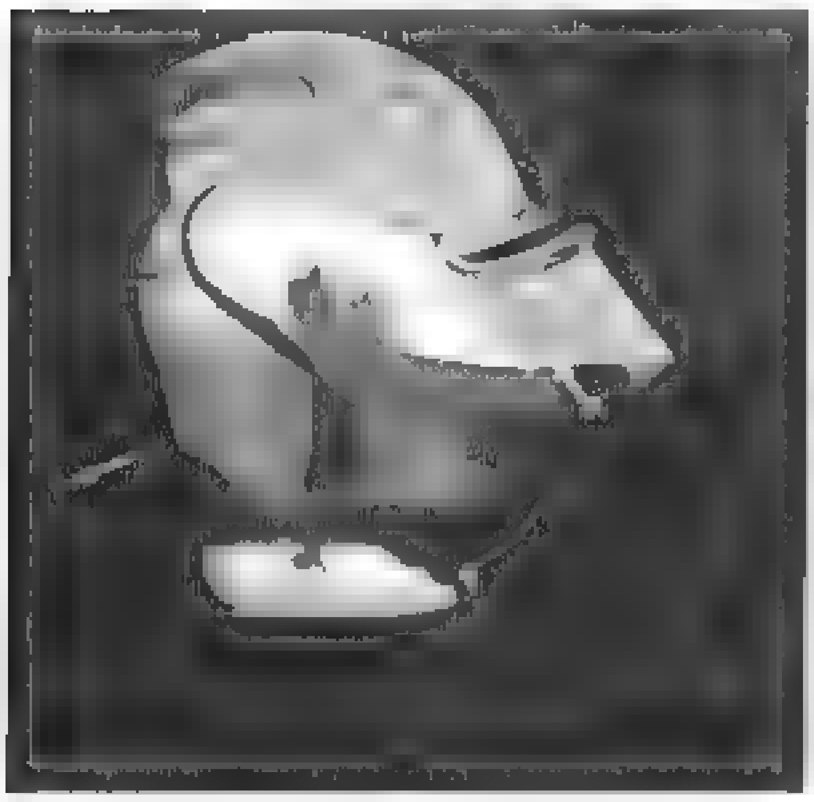
Directly involved with Mr. Flax and some of the early experimentation, Aaron Toman and Wade Allen were fascinated by armour. They started in high school metal shop, working diligently on their own and within the SCA to create some of the first, and still some of the most beautiful, armour reproductions. For years their work dominated the markets in the central region of the United States, where they influenced a whole generation of armourers who followed.

Known to reenactors as Sir Valerius Paencalvus and Will of Wilshire, the two pressed their own skills and taught a bevy of students. In addition to encouraging craftsmanship and careful research, Valerius in particular brought a passion for the chivalric arts that permeated the tone and quality of their work, an artistic elegance that became a trademark of the Valerius school as patterns, technique, and interpretation were passed to successive generations of students.

The Valerius style strives to embody the elegant simplicity epitomized by the Italian armourers of the 14th and 15th centuries. High

Figure 4.4 The founders of a whole lineage of armourers, Aaron Toman (left) and Wade Allen have stressed craftsmanship and authenticity since their start in 1979





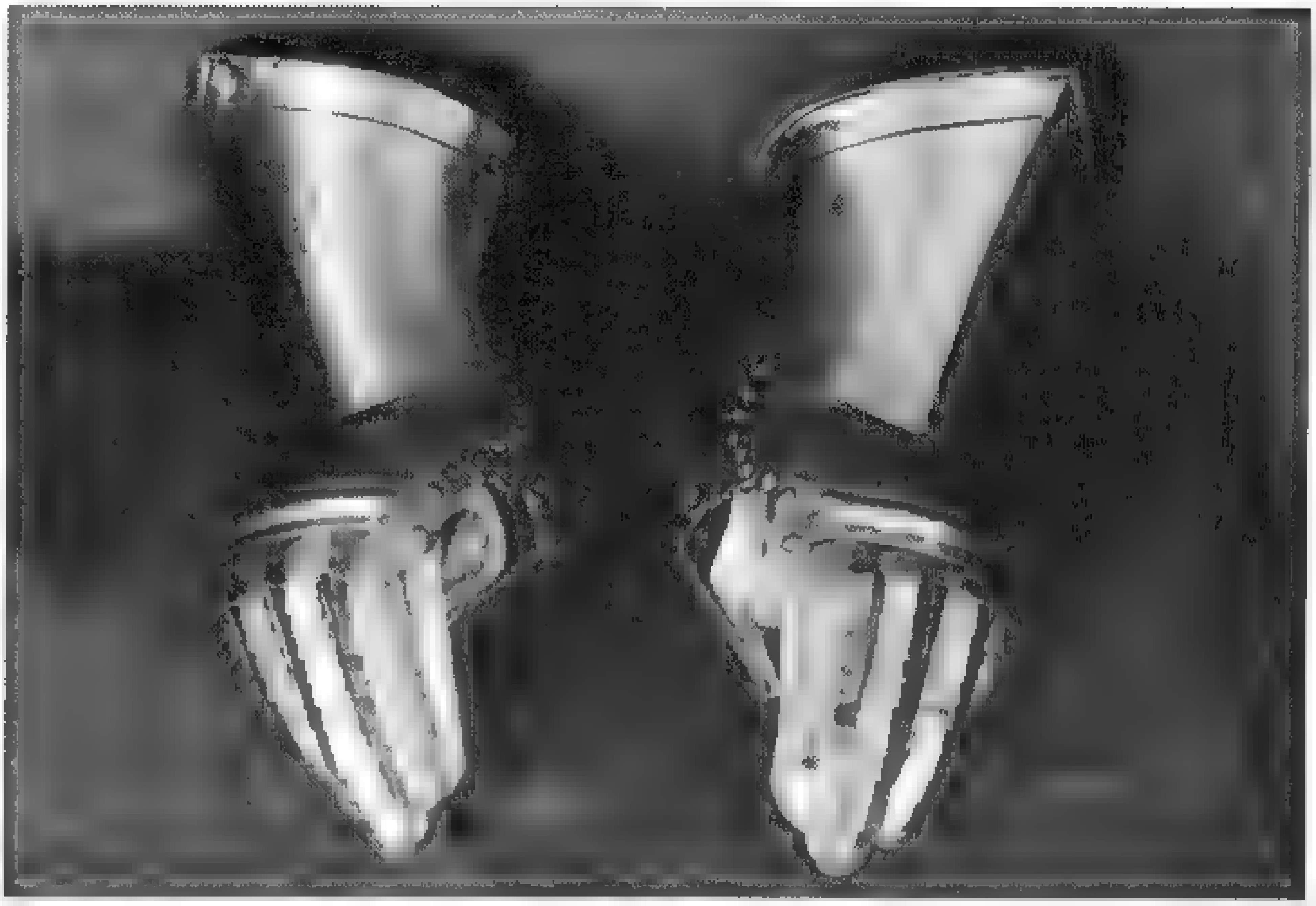


Figure 4.5. The smooth, humanistic lines of the Italian armourers characterize the work of Aaron Toman and Wade Allen, founders of the Valerius school. The students of these artisans have pursued the armourer's art with vigor, founding no less than four well-known armouries serving both reenactors and collectors. More of their work can be seen in Figures 2.6, 9.1, 10.2, 18.6, 21.3, and 21.5 (right).

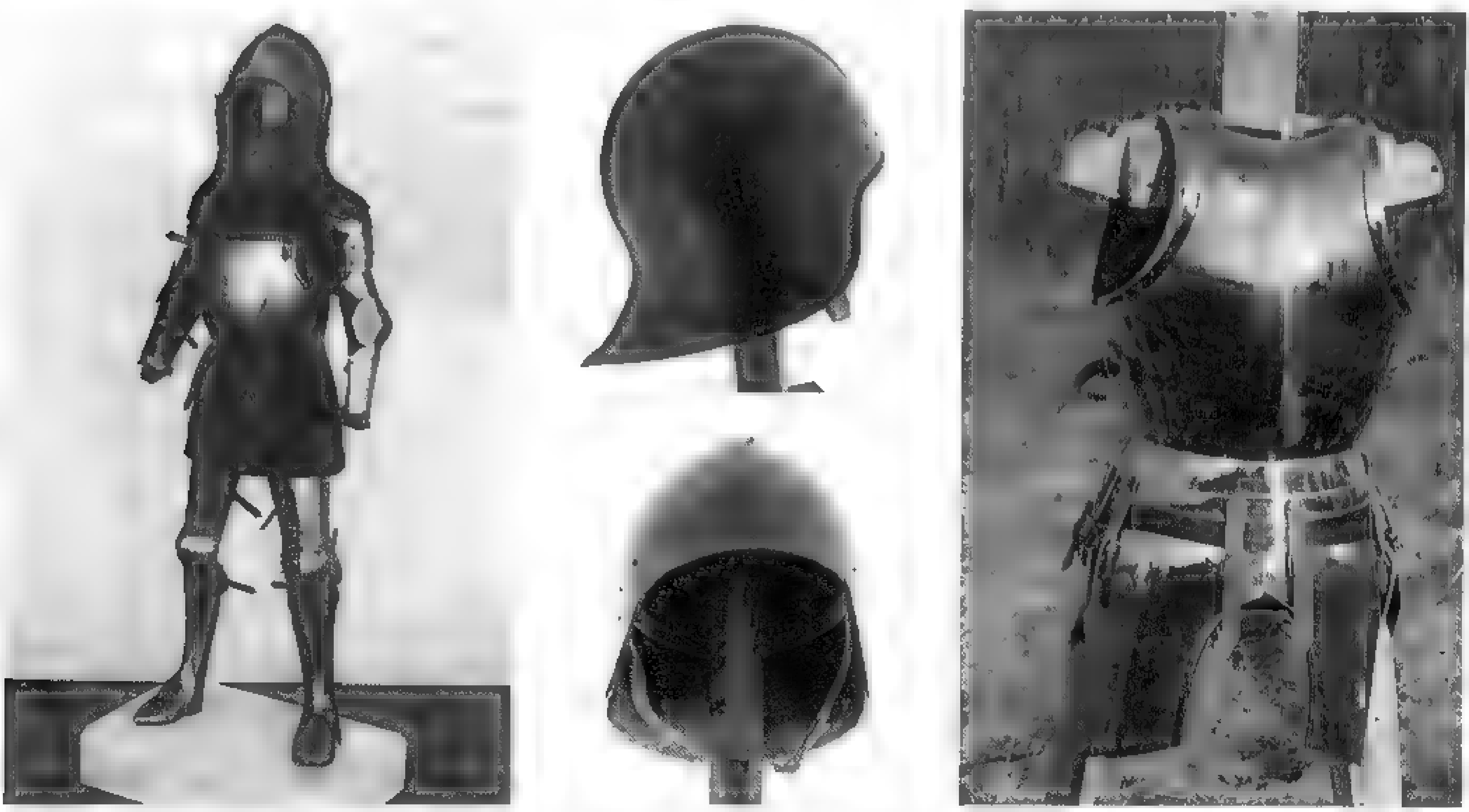


Figure 4.6. More Italian armour by Aaron Toman and Wade Allen. The transitional harness was made for a child, while the blued single piece sallet was made for a reenactor. The fact that both armourers were skilled combatants is evident from their work, since it is generally functional as well as beautiful.

Figure 4.7. The understated elegance of this reproduction of a German elbow defense typifies most interpretations of the Valerius school. The interaction of the décor does not clash with the fundamental lines of the piece and indeed are even carefully executed to enhance rather than detract from an elegant simplicity.

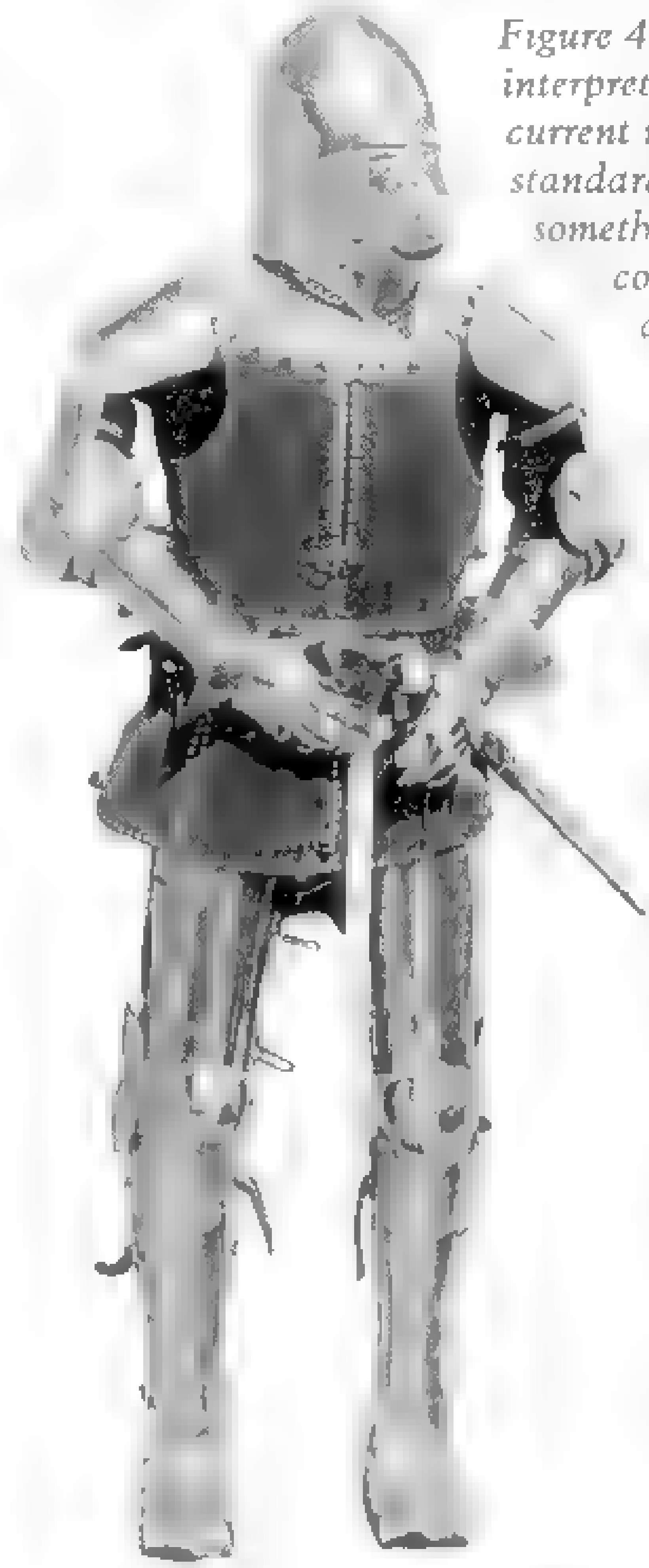


Figure 4.8. Although this interpretation is dated by current reproduction standards, it does show something of the collaborative effect achieved in the author's early days. The author and students Luke Apker and Ladislav Kuzela worked on this harness over the course of more than a month.

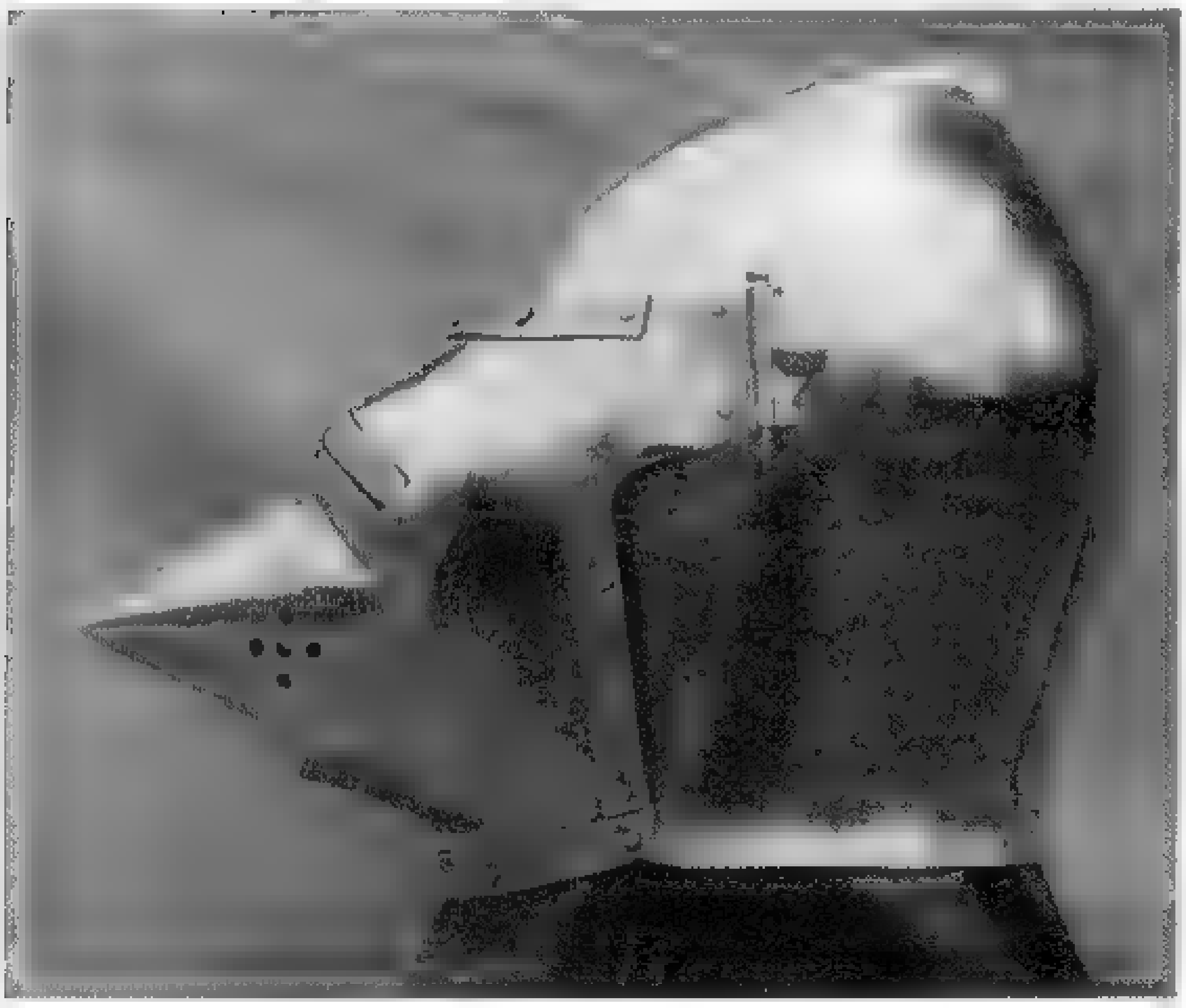


Figure 4.9. Early helmets by the author, c. 1985–1986.

polish, finished edges, and a preference for Italian design has characterized the school's stylistic preferences.

The author (Brian Price), Charles E. Davis, and Tom Justus were students in the Valerius tradition who each went on to produce a large body of work. I started my work under Valerius in 1982, massively impressed by the elegance and striking power produced by pieces in the Will/Aaron workshop, and with the added fortune of living in Milwaukee, the very same city where they worked. Upon moving to California, I began to specialize in gauntlets of the 14th and 15th century, expanding only slowly into helmets and eventually into complete harnesses.

Founded in 1984, Thornbird Arms grew rapidly under a burgeoning appreciation for the Valerius style on the West Coast. Working mostly within the SCA, I discovered another passionate armourer, a young, exceptionally talented mail-maker named Luke Apker, who joined the workshop in 1986 and rocked to local fame as he quickly built an amazing set of hammer skills. Today, Mr. Apker still works on occasional commissions, mostly for members of the SCA but also for a few perceptive collectors.

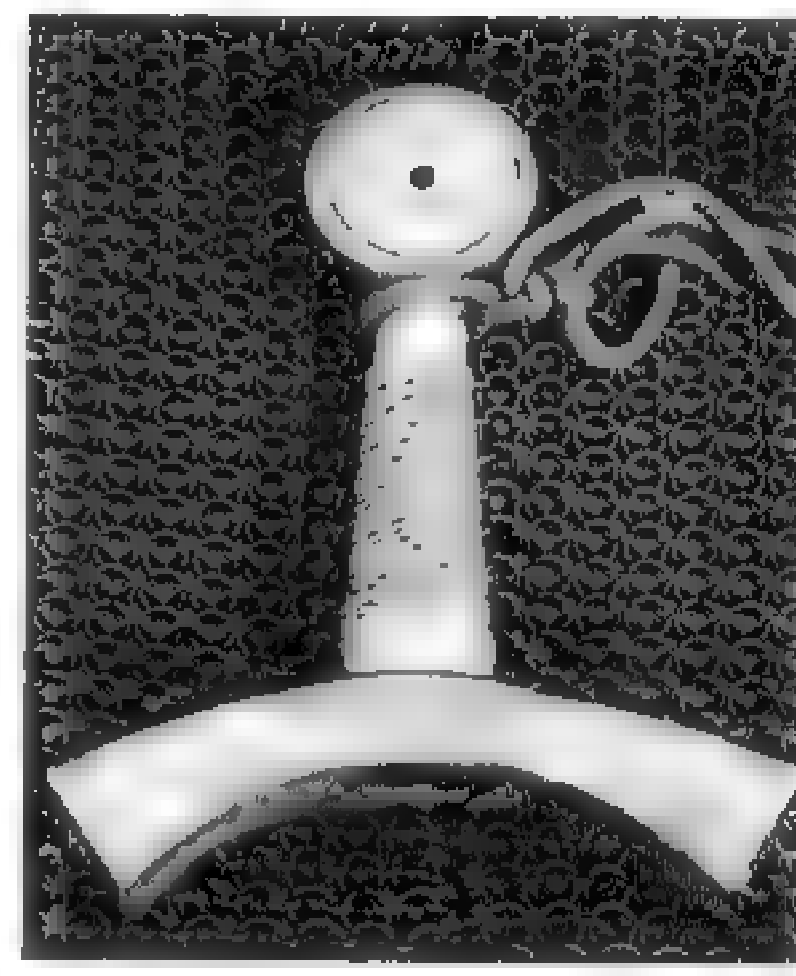
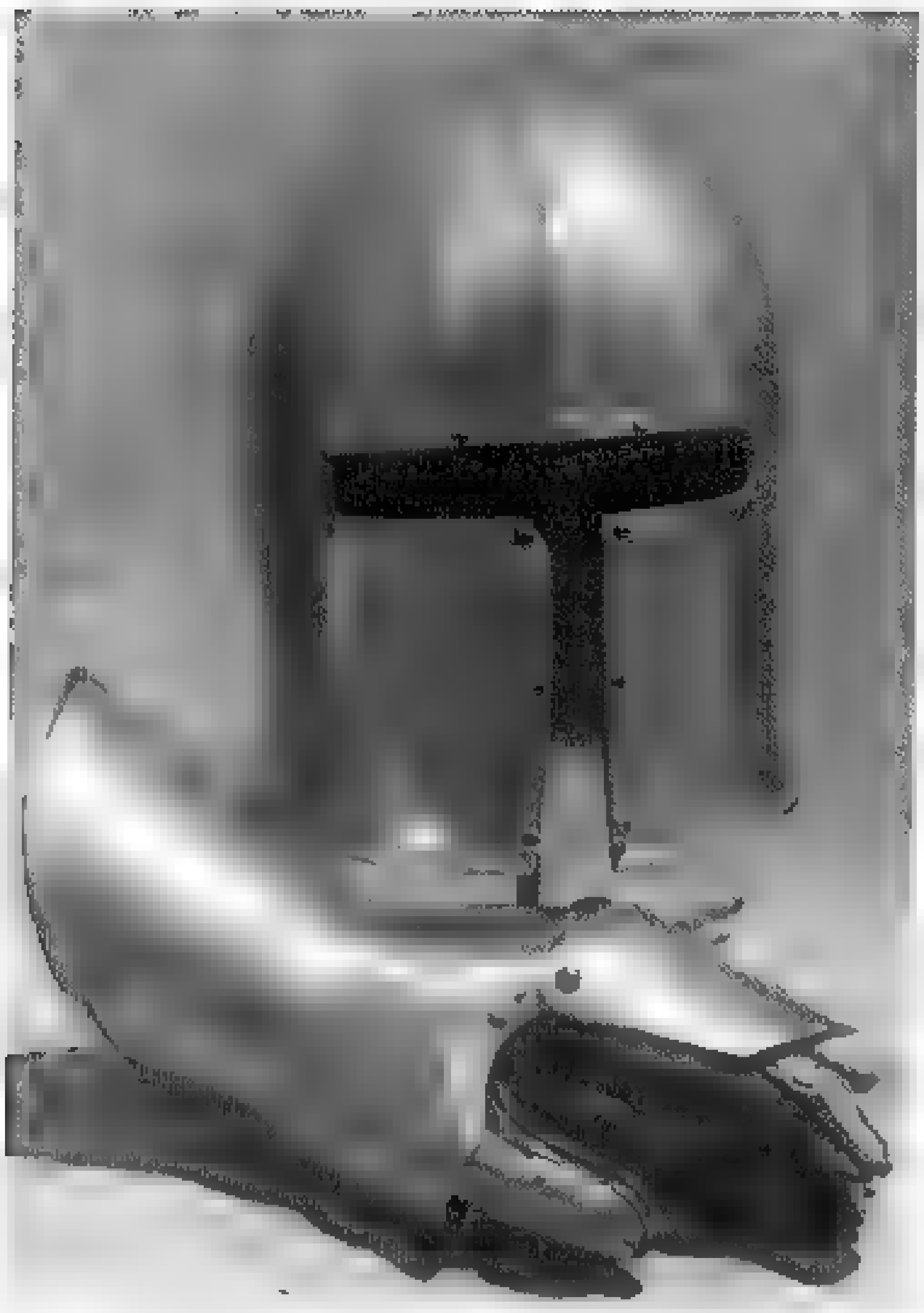


Figure 4.10. The author is probably best known for work with gauntlets, especially the finger gauntlet style pioneered by Aaron Toman in 1980–1981. These were made for a client in 1989, and the sword hilt at right was made for béhourd reenactments in 1991

Figure 4.11. The author currently works chiefly on Italian armour from the 14th and 15th centuries, as this mid-15th century Italian arm shows



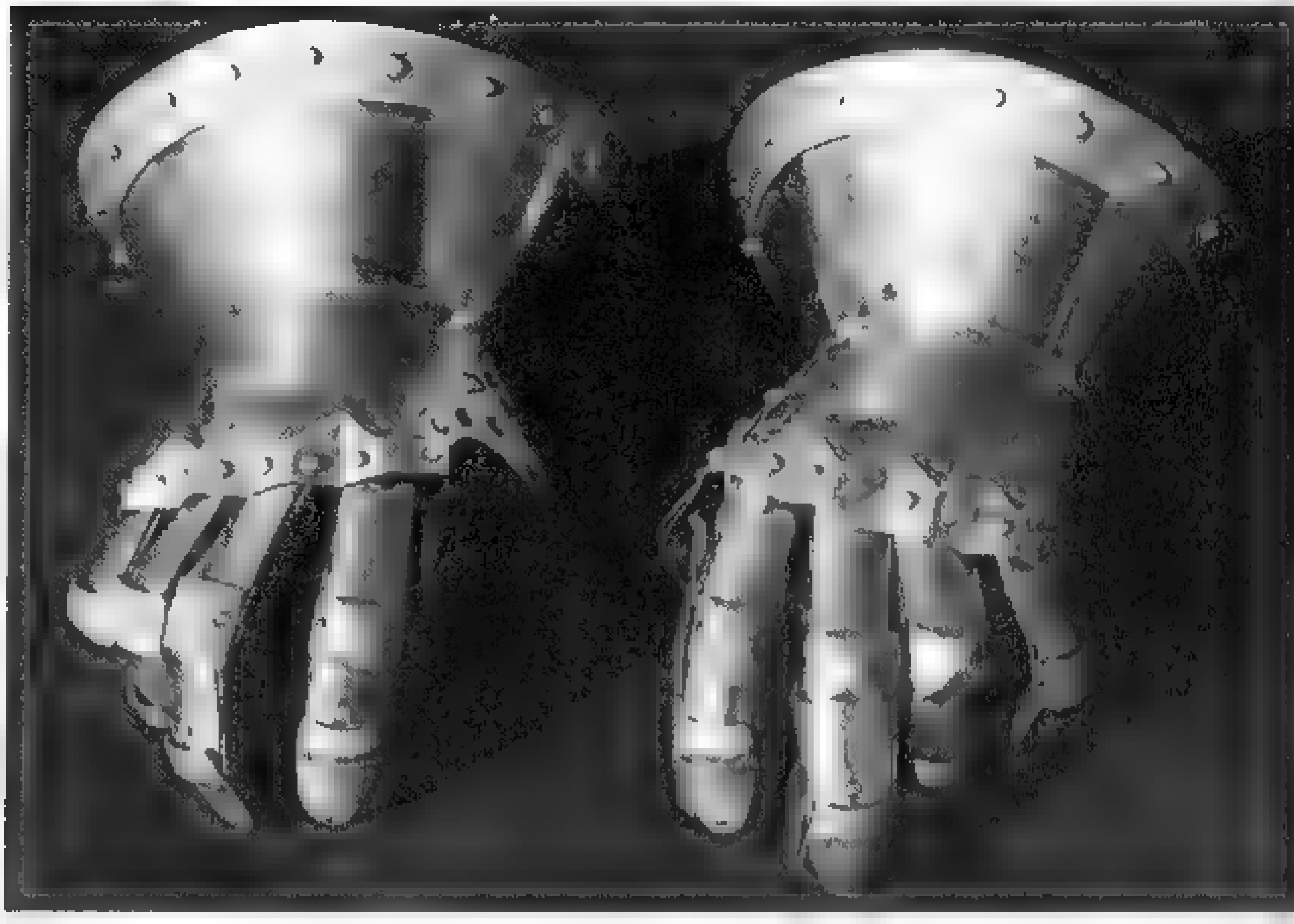


Figure 4.12. Early finger gauntlets and Milanese work by Luke Apker of Los Angeles, California, the author's former student. A gifted hammersmith, or "plattner," Mr. Apker has produced work of great beauty during his career

Figure 4.13. A loosely affiliated member of the Valerius school, Brent Junkins runs a full-time armoury, Anshelm Arms, that provides equipment to many tournament company and béhourd society combatants. Among his strengths is an ability to provide complete harnesses with buckles, belts, spurs, and other accoutrements. More of his work can be seen in Figures 4.3 and 20.11

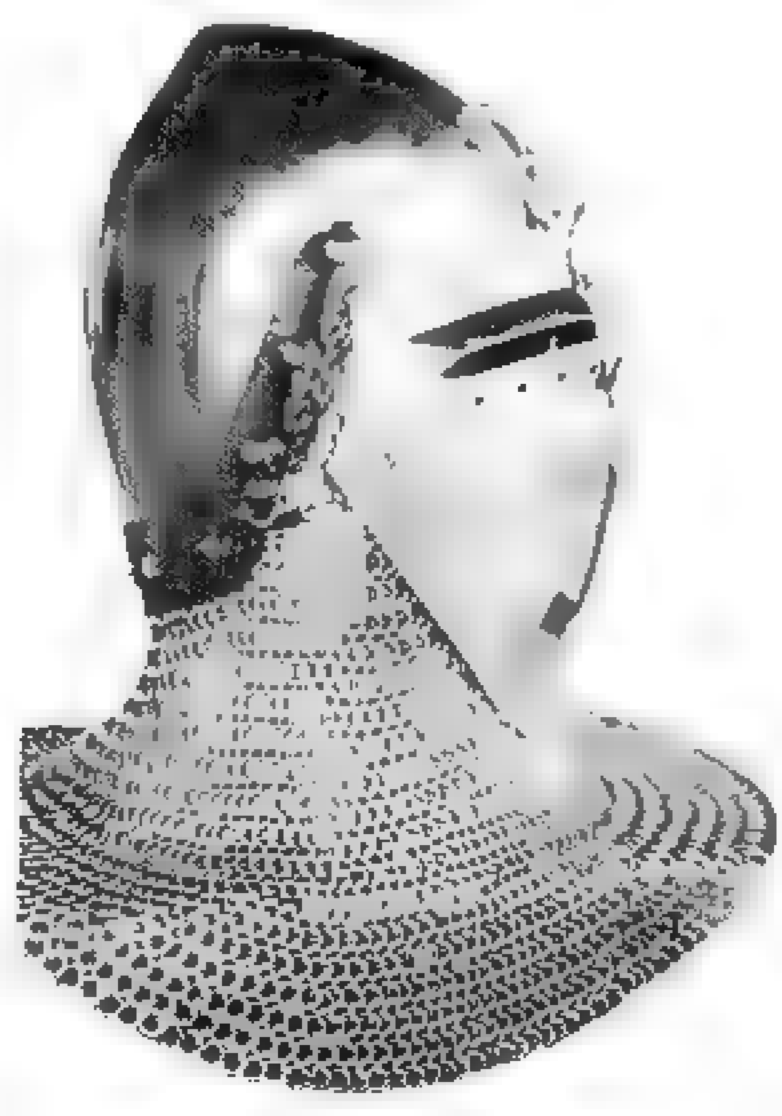


Figure 4 14 Charles Davis, working under the armoury name Mallet d'Argent, has produced some fine reproductions. A student of Aaron Toman, Mr Davis now produces pieces part time and has begun more aggressive use of authentic raising techniques. His work can be seen throughout the book (see figs. 6 45, 17.2, 18 6, and 23 12)

Thornbird Arms closed in 1990, but in that same year another young apprentice came into the workshop, Brent Junkins. Mr. Junkins worked steadily within the style, arduously driving through the body of techniques to develop his own artistic wings, founding Anshelm Arms in 1991. This armoury has prospered, building a reputation for quality pieces done within the constraints of reenactor parameters, function, and price.

Another armourer strongly influenced by the "Valerius West" school is Steve Schroeder, an armourer practicing in the northern California Bay Area. Unlike many Valerius school armourers, Mr. Schroeder tends to favor the more linear German armour of the 15th century. An active combatant within the SCA and a member of the Company of Saint George, Mr. Schroeder seems to have a gift for detail work and a sincere love for the craft. He is known especially for his interpretation of the German sallet, building innovations in function to allow the use of the sallet within SCA combat parameters. As a result of these efforts, the sallet, sleek of line and possessing an imposing visage, is now a popular helmet on the American West Coast.

Mr. Toman's other student, Charles Davis, continues to produce armour for reenactors on a small scale, preferring to refine his technique rather than surviving on munitions armour. Mr. Davis has been working as an armourer for 15 years, producing pieces for tournament companies and reenactors. He is one of the few skilled armourers who cares to work in stainless steels, something that is highly desirable in the reenactment community, even if a modern solution to the medieval problem of rust and maintenance.

Like other students of the Valerius school, Mr. Davis tends to focus on work of the late 14th and mid 15th century. His lines are mostly Italian in origin, but he has done excellent pieces from other periods as well.

Wade Allen left the reenactors community for a career in computers, eventually relocating to the American East Coast, where he began working with a young talent named Tom Justus. Known to reenactors as Eldrid

Tremayne, Mr. Justus produces armour for a variety of clients, both in romance groups and for historical reenactors. Increasingly interested in working with spring steels and using hardening techniques, Mr. Justus is one of the most gifted armourers who continues to work full-time.

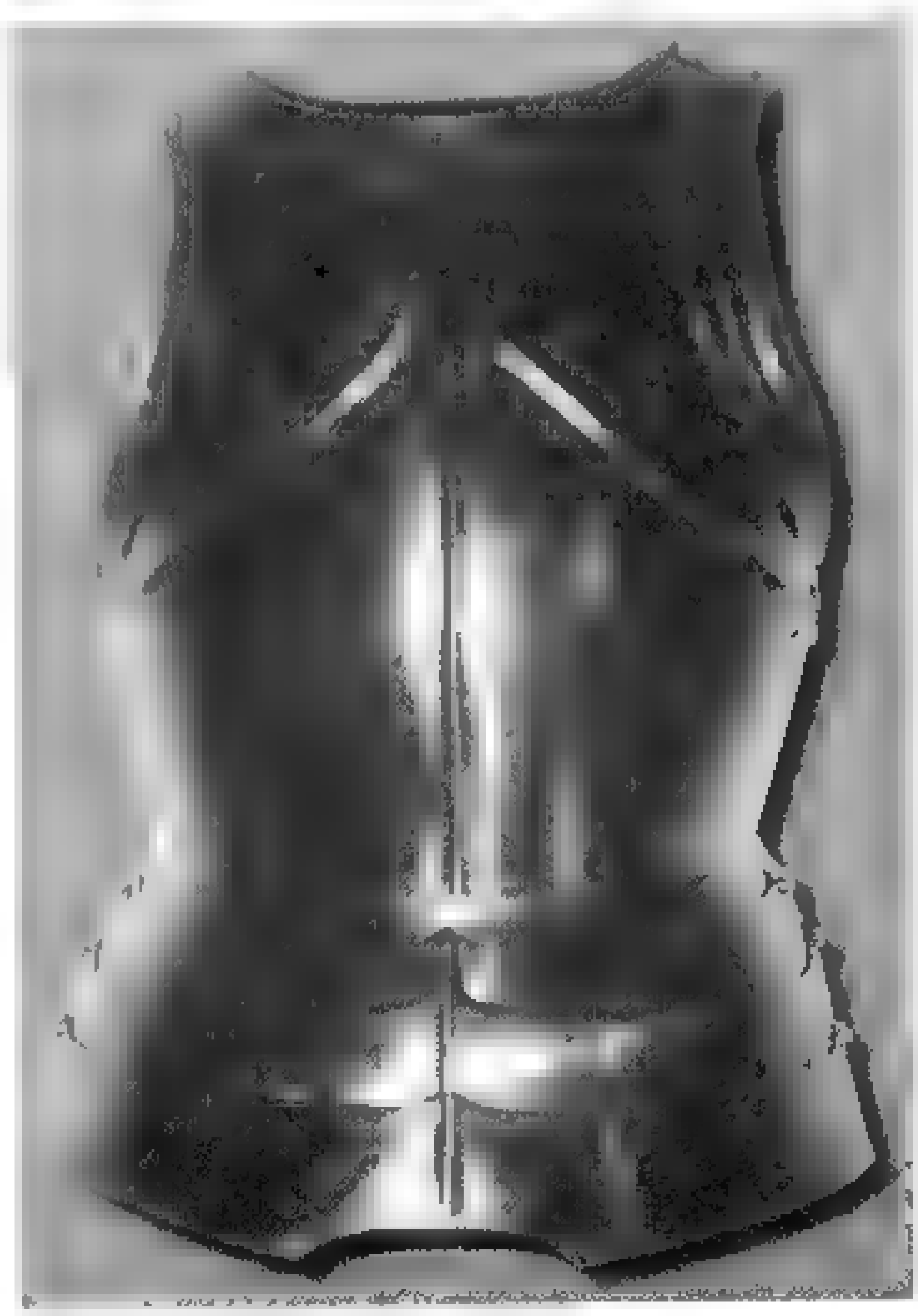
One of Mr. Justus' best former students, Jessica Rechtschaffer, is perhaps the only practicing female armourer in the world today. Working also with a Valerius heritage, her work is a credit to the community, and she often provides guidance to lady combatants, helping them to adopt a more authentic and yet functional harness.

Greg Anderson, producing under the tradename Mandrake Armoury, has worked in the same transitional style favored by the Valerius school armourers, but rather than focusing on the higher-end pieces, he has done a great service by producing exceptionally reasonably priced munitions versions of armour from the late 14th century. He has consistently selected pieces for their practicality and correct style from the period, adapting designs for low-cost production and use in béhourd societies.

All of the Valerius school armourers seem to share a passion for authentic construction techniques, chivalric feats of arms, and the expression of the knightly ideals both within the work and on the field The author and other members of the school have fought passionately for more authentic construction techniques, attempting to impart the value of correct technique to the reenactment community. Valerius school armourers continue to exhibit a preference for armour from the 14th and 15th centuries, in particular armour in the Italian style, and elegant raising work has become an important component of their work. Each armourer has at least one student, and it is probable that some of these students will go on to pass the knowledge down to successive generations of young armourers.

The Western School

The other body of craftsmen who can be grouped into a school would be what I call the "Western" armourers, so-called because they are loosely grouped in the American Pacific



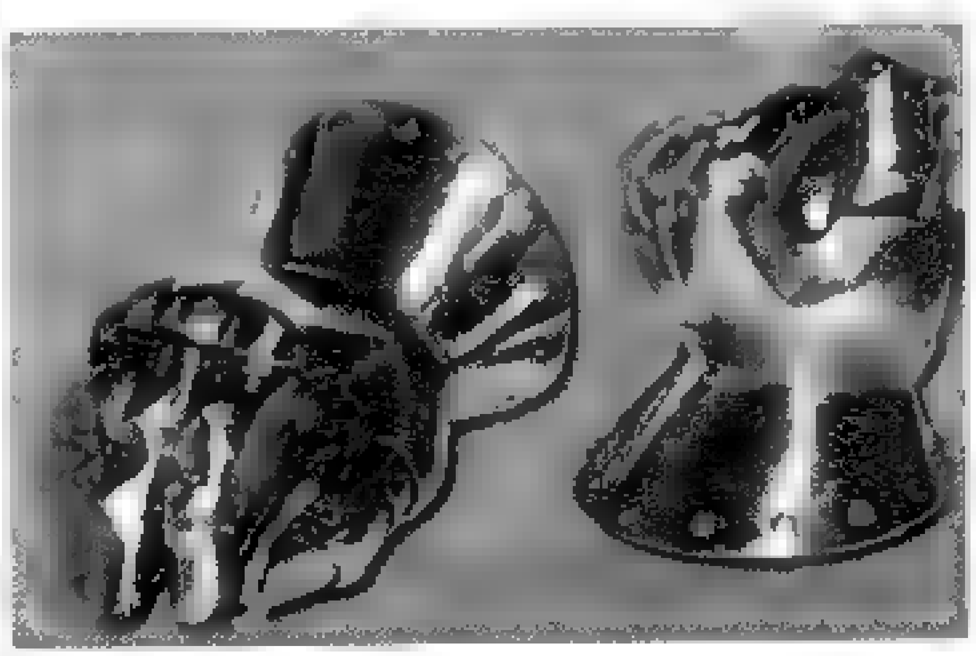


Figure 4 15. Jessica Rechtschaffer, a one-time student of Tom Justus, works primarily in the 14 century style

Northwest and Northern California. Their proximity has created similarities in design and engineering such that armour from the region is recognizable, evolving over time to favor armour from the very late 15th and early 16th century Germany. It provides an interesting counterpoint to the Italian school favored by the Valerius school armourers.

Historically, this group traces its lineage to Jeff Williams and James Earley, early SCA participants who drove the development of armouring technique on the West Coast.

James Earley has made armour for 30 years, working primarily for clients within the SCA. Although heavily adapted for use in SCA combat, his designs have proven very influential in the northwestern region of the United States; hundreds of Earley bascinets are still in use with tournament reenactors, and it was Mr. Earley who first advocated the use of and provided transitional harness to the region.

Personally, Mr. Earley has fought competitively and often, maintaining his martial edge and incorporating these skills into his craft. He still produces armour full-time but does not restrict his commissions to a particular place and time, considering work from almost any medieval period.

While the descendants of these armourers were not direct students, they were influenced by the techniques and finished pieces of the pace-setting armourers in the region. To be sure, there were other armourers who drove the style, particularly James Bliss and Robert Mackenzie (Mackenzie-Smith Armouries), but in the long term the three mentioned above seem to have dominated the development of armouring style in the region.

The Western school does not possess the stylistic cohesion shown by the Valerius

Figure 4 16. Steve Moffet a Bay Area armourer, is especially skilled at detailing and locksmithing elements (buckles clasps, etc). He is well known for adding intricate detailing to his work, and his flair for the 16th century supports this interest well Part of Mr. Moffet's artistic impulse seems to be the creation of a complete picture, correct in all details

armourers but rather is characterized by a rich diversity of preferences that tends to favor the sleekness and adornment found in German armour, especially from the mid 15th and early 16th centuries. There is a fondness for elaborate detail expressed in fluting, roping, and etching.

In Northern California there is a rich concentration of skilled armourers. For years, Steve Moffett and Tom Huguenin worked together under the name All Saints Armoury, producing well-crafted, highly detailed pieces primarily, though not exclusively, for the SCA market. Though they now work separately, each earned a reputation for producing excellent work using constructed techniques (where complex elements such as helmets and gauntlets are made from several pieces welded together rather than formed from a single sheet). Especially fine were the details of latches, catches, and piercework often added to the late 15th and early 16th century pieces that

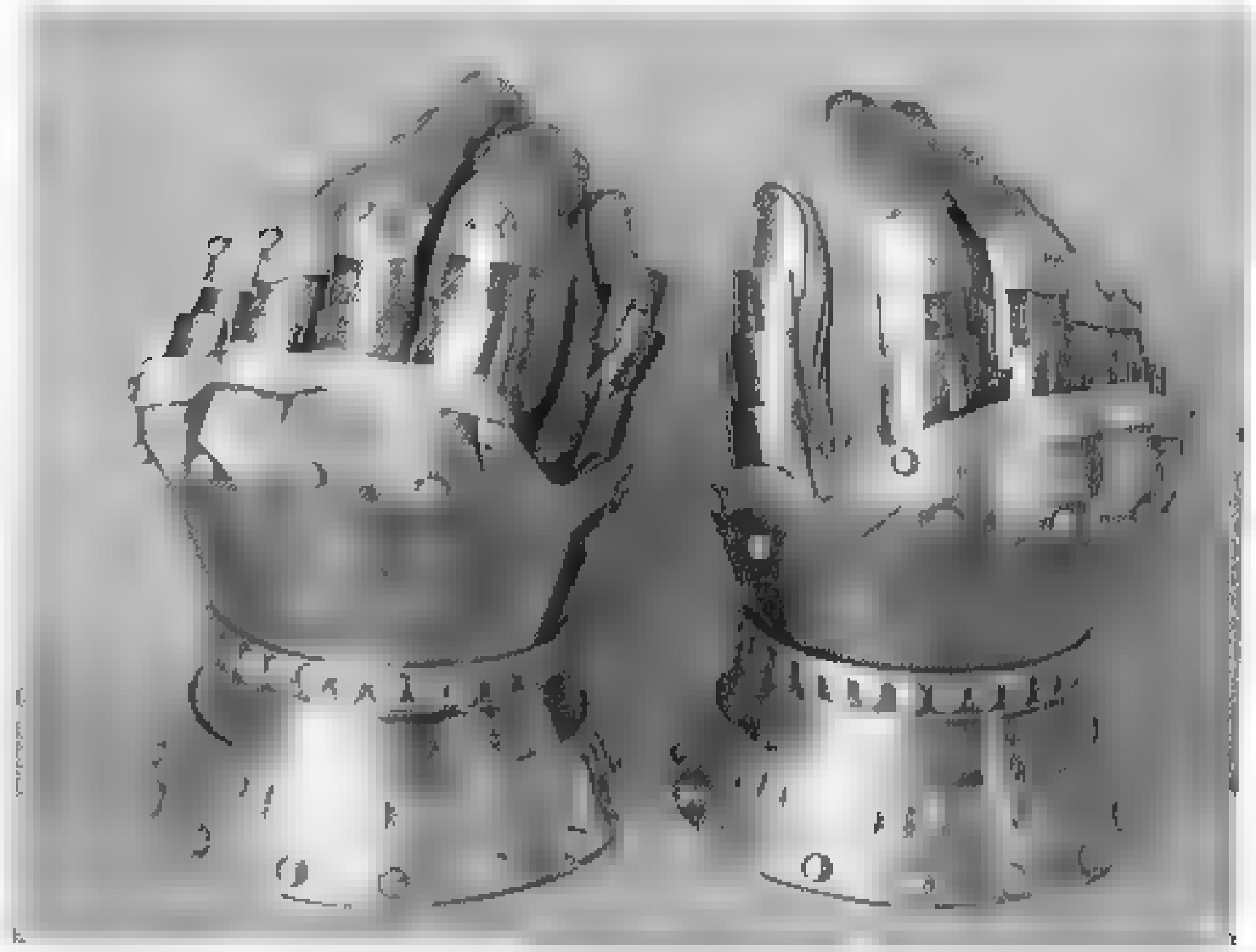


Figure 4.17 Although mostly training new armourers due to an injury, Tom Huguenin produced a respectable body of work, working primarily under the All Saints Armoury name.

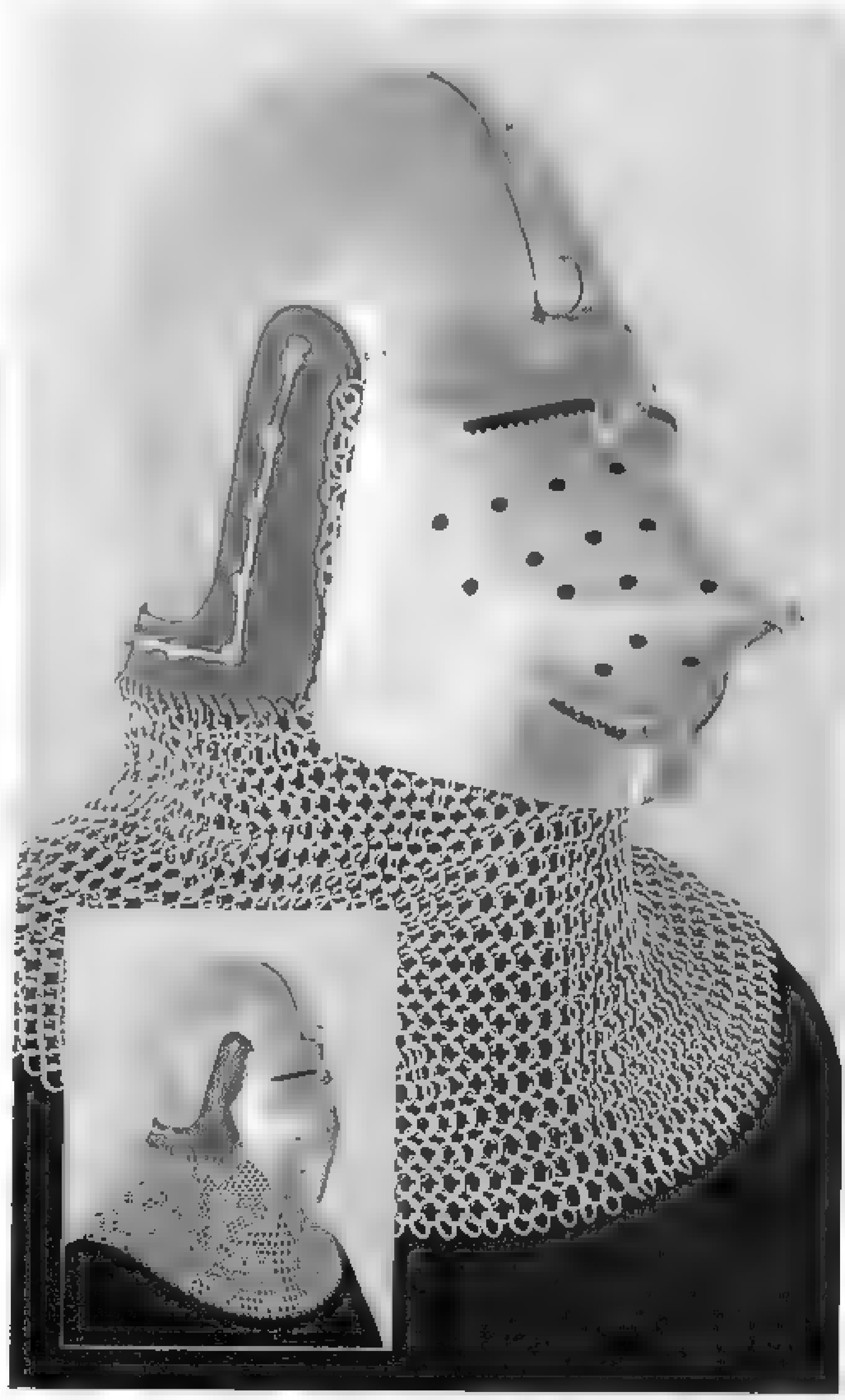


Figure 4.18 Christian Fletcher has earned an excellent reputation for good work with an exceptionally high level of customer service.

form the bulk of their work. Each maintains a flair for detail and a love for the armour itself. Mr. Moffett tends to favor pieces from 16th century Germany, while Mr. Huguenin has favored 14th and 15th century pieces.

Non-School Affiliated

There are probably a hundred armourers who are unaffiliated with either the Valerius or Western schools, and sadly there is insufficient room in this volume to feature them all. Many produce munitions-quality pieces for use within the sports practiced by the living history societies, but there are a few who have gone far beyond this.

Christian Fletcher

Christian Fletcher of Nampa, Idaho, provides armour for clients in various reenactment societies and for collectors. He has a superb business reputation, and his clients give him exceptionally high marks for on-time quality delivery. Focusing on mixed-media armour from the 13th and 14th centuries, Mr. Fletcher has been working in the craft for about 10 years.

For Mr. Fletcher, as with many of the practicing armourers in this gallery, "mastery" of the armourers craft is seen as an elusive, probably impossible goal. It is the journey toward a distant ideal that is important, a journey that he says is rewarding in its own right. I suspect that most of the armourers would agree with his sentiment.

Figure 4 19 Joseph Piela is best known for his Classical interpretations, as this flagship Roman cavalry helmet attests.

Joseph Piela

Working out of Florida, Joseph Piela tends to favor classical armours from premedieval Greece and Rome. Unlike most armourers working for reenactors, Mr. Piela has a background in art and metalworking, skills he uses to execute some helmets in one piece using raising and chasing techniques.

James Gillaspie

Another armourer with an art background is James Gillaspie of Flagstaff, Arizona. An armourer who has been working with collectors and high-level reenactors for more than 15 years, Mr. Gillaspie is perhaps the first of the American armourers to work in heat-treated spring steels, and his advocacy of the use of correct materials has now permeated to most of the high-level armourers.

Although he has done some excellent quality Milanese reproductions, Mr. Gillaspie is best known for his work in German Gothic armour from the late 15th century, and it is clear that this is the style that has captured his artistic imagination. His feel for the period is certainly excellent, and to this disposition he has added some valuable first-hand examination of the fine Gothic harnesses by Lorenz Helmschmied.

Like many of the better armourers, Mr. Gillaspie will work on individual pieces but strongly prefers the opportunity to craft complete harnesses for discriminating clientele.

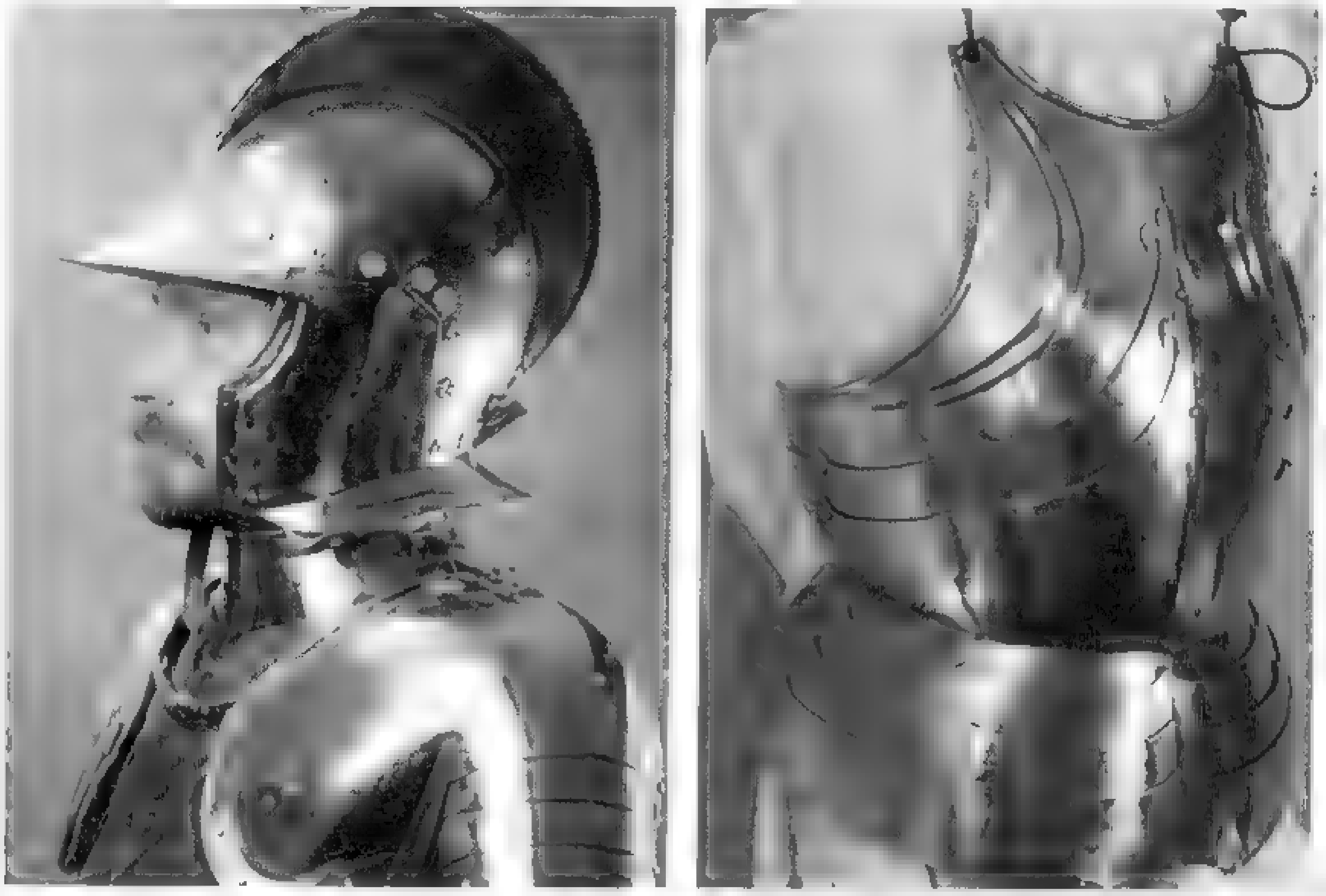


Figure 4.20. James Gillaspie has been producing pieces of increasing crispness through the years. He is mostly known for his affinity for armour in the Helmschmid style but he can execute other styles as the 16th century harness above shows. His other work may be seen in Figures 1.1 and 16.1

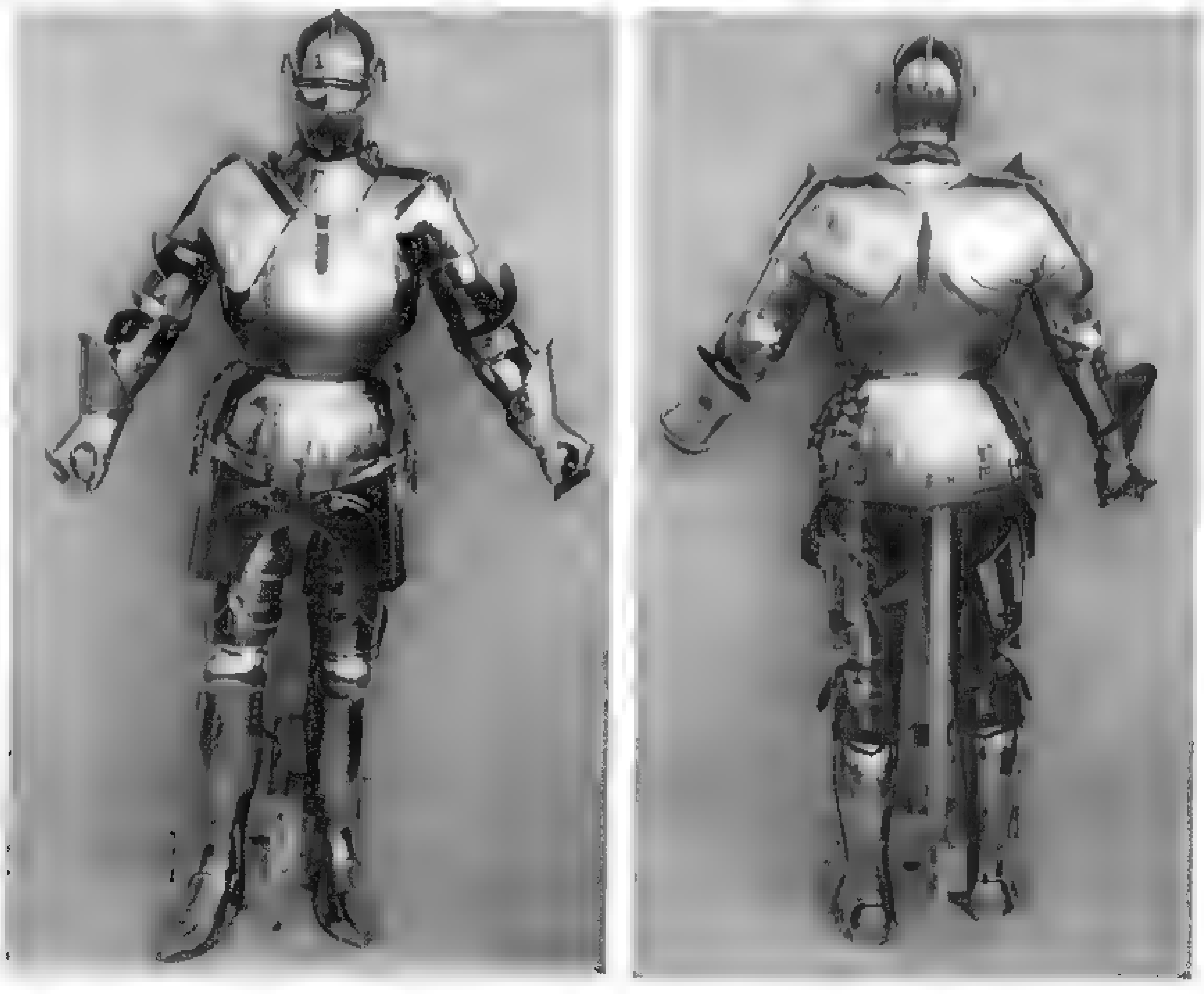


Figure 4.21. A fine Milanese carefully wrought by James Gillaspie. Mr Gillaspie is best known for his German Gothic armour, but this fine example demonstrates his often overlooked stylistic breadth

Figure 4.22 Robert Valentine, with his business Valentine Armouries, is based in Calgary, Canada. Working aggressively, Mr Valentine has created a large body of work and pursued the armourer's art with vigor and enthusiasm. Much of his work recreates pieces from the 16th century, as in the two harnesses above. His work can also be seen in Figure 4.23

Robert Valentine

Working for more than 17 years, Robert Valentine of Calgary, Canada, has brought his own artistic background to bear (he was previously an oil painter) in creating full harness from the late 15th and 16th centuries. Perhaps one of the most prolific of the modern armourers, Mr. Valentine works mainly for collectors and the entertainment industry.

What seems to capture Mr. Valentine's attention is the spectrum of expression available through steel as a medium of artistic expression. Using mixed media, repoussé, and bluing, he expresses himself freely within the work, a true artist in a lost medium. Working out of a large workshop, Mr. Valentine tends to produce armour that is highly adorned. Recently he has created a videotape of armouring technique, *Crafting Medieval Armour*, and has a large Web site dedicated to his reproduction work, including many fine photographs of his creations.

Peter Fuller

One of the few North American armourers with a curatorial background, Peter Fuller, also

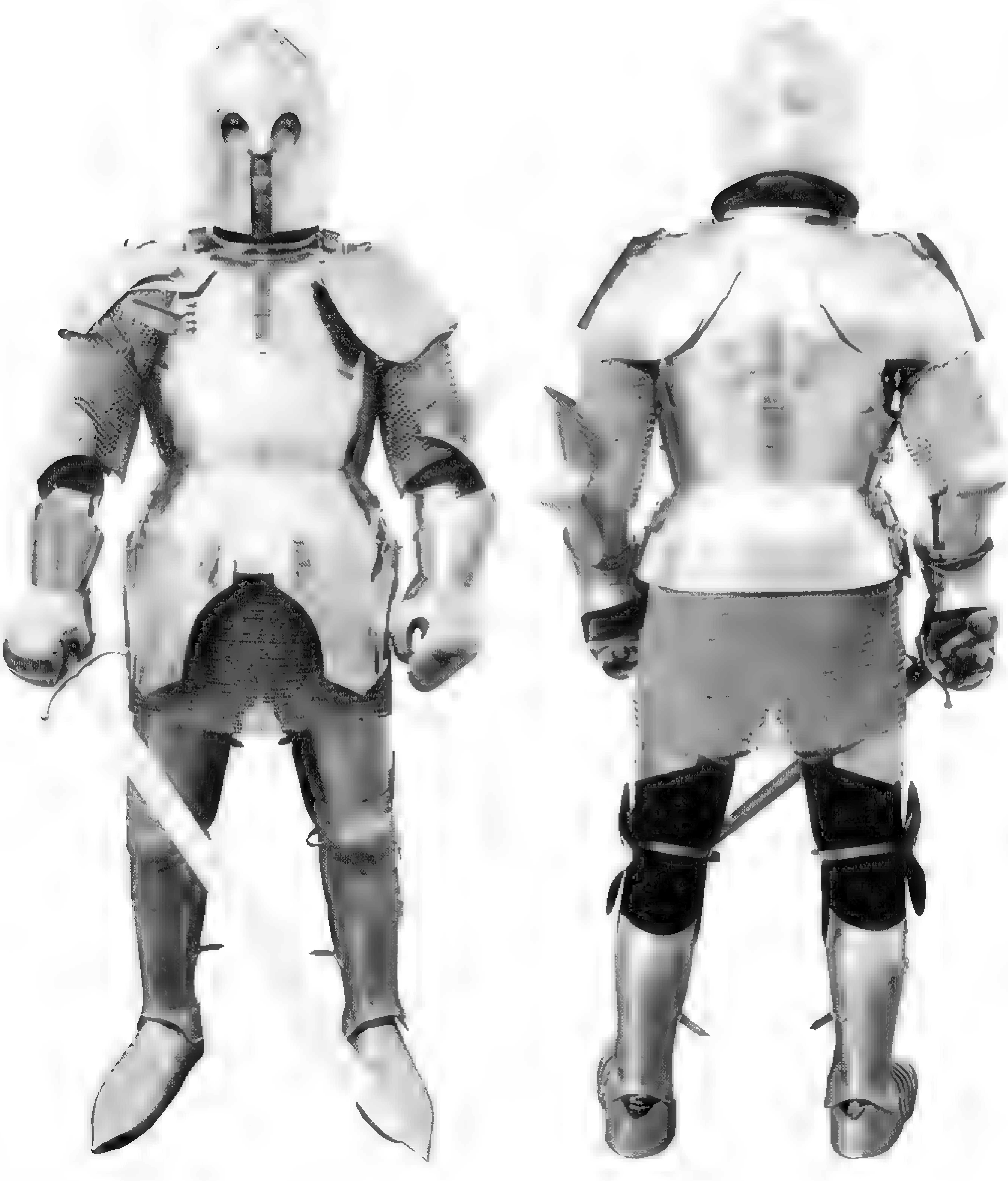


Figure 4.23 Robert Valentine produces armour from virtually every historical period, as with the Italian harness above (c. 1450). He is adept at creating the small locksmithing elements such as hinges, catches, latches, and buckles for finishing a medieval harness properly.

Figure 4.24 Surprisingly, Peter Fuller is relatively unknown in the arms and armour community, but his curatorial background lends his work a reproduction quality that is seldom seen. Focusing his work on the 14th century, he also produces pieces from a wide variety of periods as can be seen in Figures 1.3, 1.4, and 11.1.

of Calgary, Canada, strives to create pieces at as high a quality level as possible. Leveraging his museum contacts and first-hand experience handling medieval originals, Mr. Fuller has done some very interesting reproductions, albeit mostly using the constructed techniques rather than raising. An active participant in studies into swordplay and the history of arms and armour, Mr. Fuller is quickly earning a strong reputation among the higher level reenactors and will likely continue to secure his place among the worlds most impressive young talents.

One of Mr. Fuller's strengths is his facility with armour from a wide variety of periods, though he personally tends to participate in reenactment events from the mid 14th century.

Theodore Monnich

Another museum curator-cum-armourer, Theodore Monnich is chief conservator with the South Carolina State Museum. Although he does not produce a large body of work, his reproductions are of exceptionally high quality and are very close to the medieval originals. Looking at the work produced by both Mr. Fuller and Mr. Monnich, the benefit of contact with the medieval originals expressed in their efforts is clear.

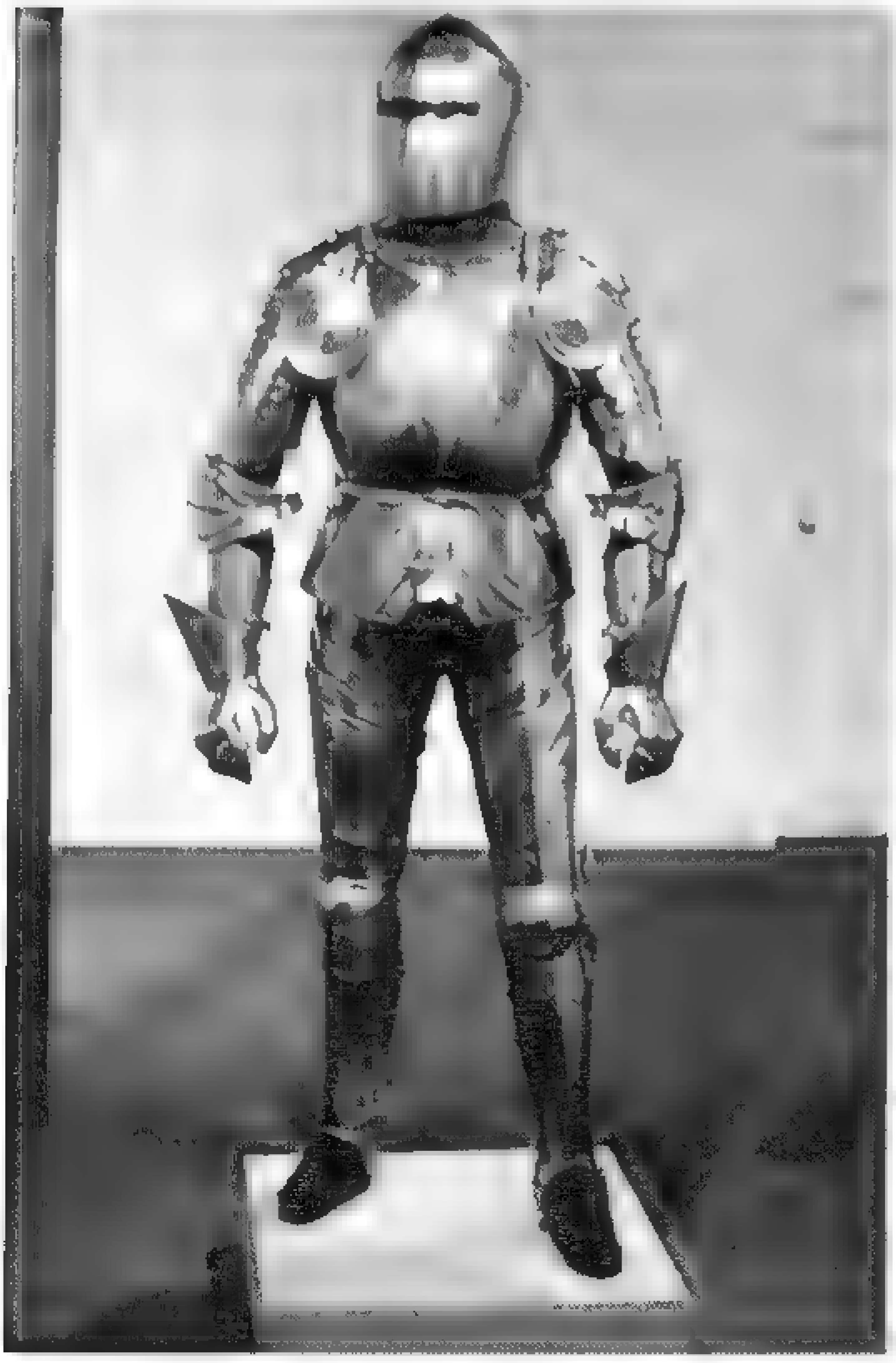
Mr. Monnich has a talent for working in mixed media, including cuirboille, gold leaf, and steel. Attending some of the larger pas d'armes, he has stunned the gallery with his complete presentations of a knightly

challenger. More than just an armourer and combatant, Mr. Monnich has studied a wide range of topics relating to the armourer's craft; he is an important source of information relating to metallurgy, shields, crests, and armouring techniques in general.

Robert MacPherson

Without question, the finest armourer in North America is Mr. Robert MacPherson. Working out of Ithaca, New York, he has many years reenactment and collector experience.

Mr. MacPherson has consistently pushed the envelope in terms of correct medieval technique, generally eschewing the welding techniques employed by most other armourers in favor of pulling helmets, poleyns, and couters from a single piece of



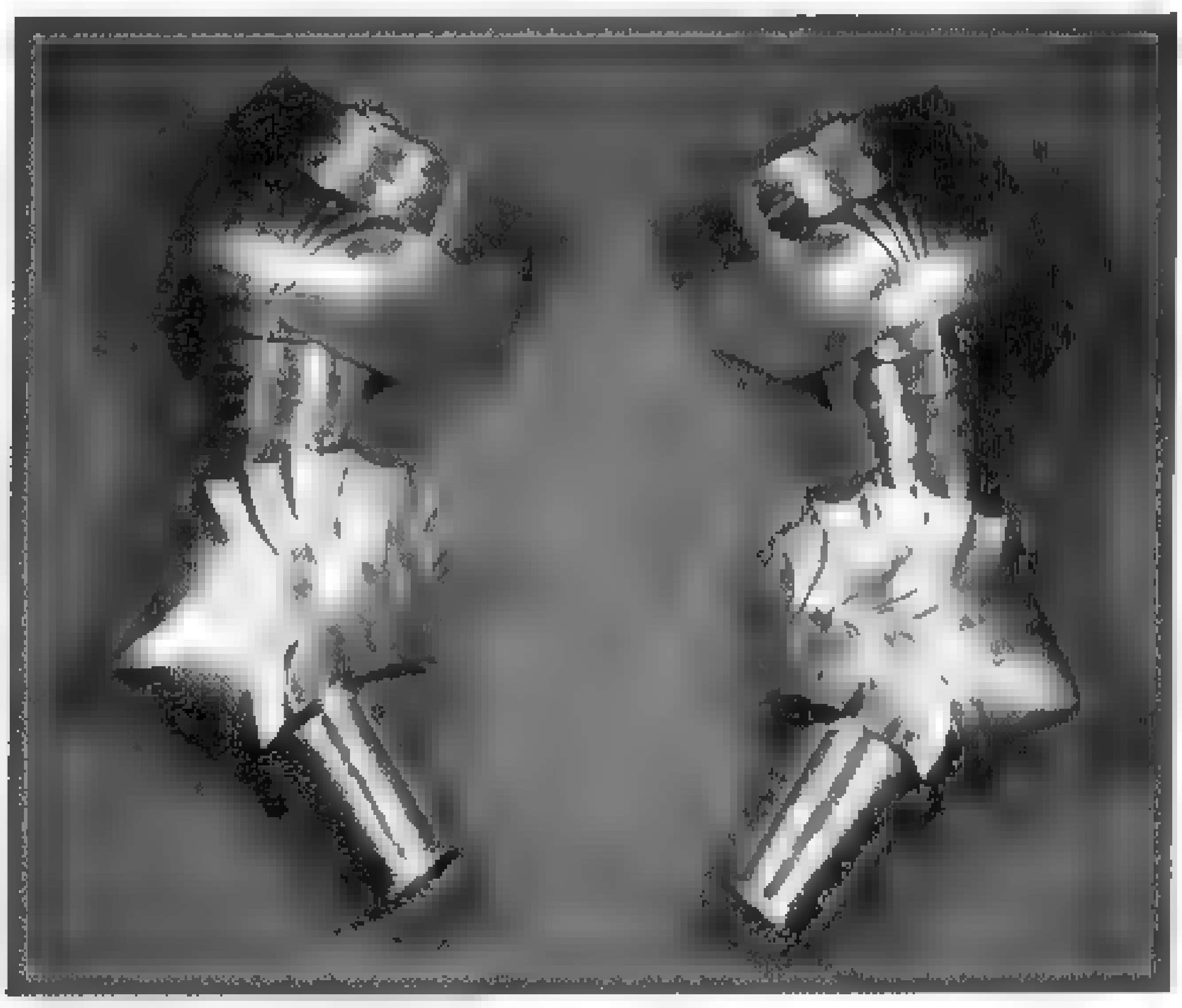


Figure 4.25. A conservator with the South Carolina State Museum, Theodore Monnich works primarily in the German style, effectively capturing the feel of pieces from the 15th and 16th centuries. His work can also be seen in Figures 5.2, 6.32, 10.1, and 18.6

raised steel. In recent years he has produced a variety of full harnesses from the 14th, 15th, and 16th centuries, continuing to stretch his already potent skills with hammer and stake. He works in both mild or hardened and tempered spring steels, depending upon the client's needs.

Working alongside Mr. MacPherson is his lady wife, Marianne Hansen, who does the etching as well as produces pewter castings and dress accessories for reenactors who recreate middle-class people of the Middle Ages. Her work sets the standard for such medieval artifacts at a high level of accuracy and quality, all made in the correct medieval manner. She has also produced a beautiful sallet, pictured below (fig. 4.26).

Armourers in England

Although I do not know the majority of reenactor armourers from England, there are several reproduction-class armourers who must be mentioned.

Chris Dobson, formerly Master Armourer at the Royal Armouries, Leeds, now executes commissions for collectors and restoration work for an exclusive stable of regular clients. Mr. Dobson tends to favor the Milanese armourers of the 15th century and has recently begun to conduct more intensive research into the records such armourers have left behind.

I can think of no better man to end the gallery with than Mr. William Radford. Working in relative isolation, he produces what many believe to be the finest armour

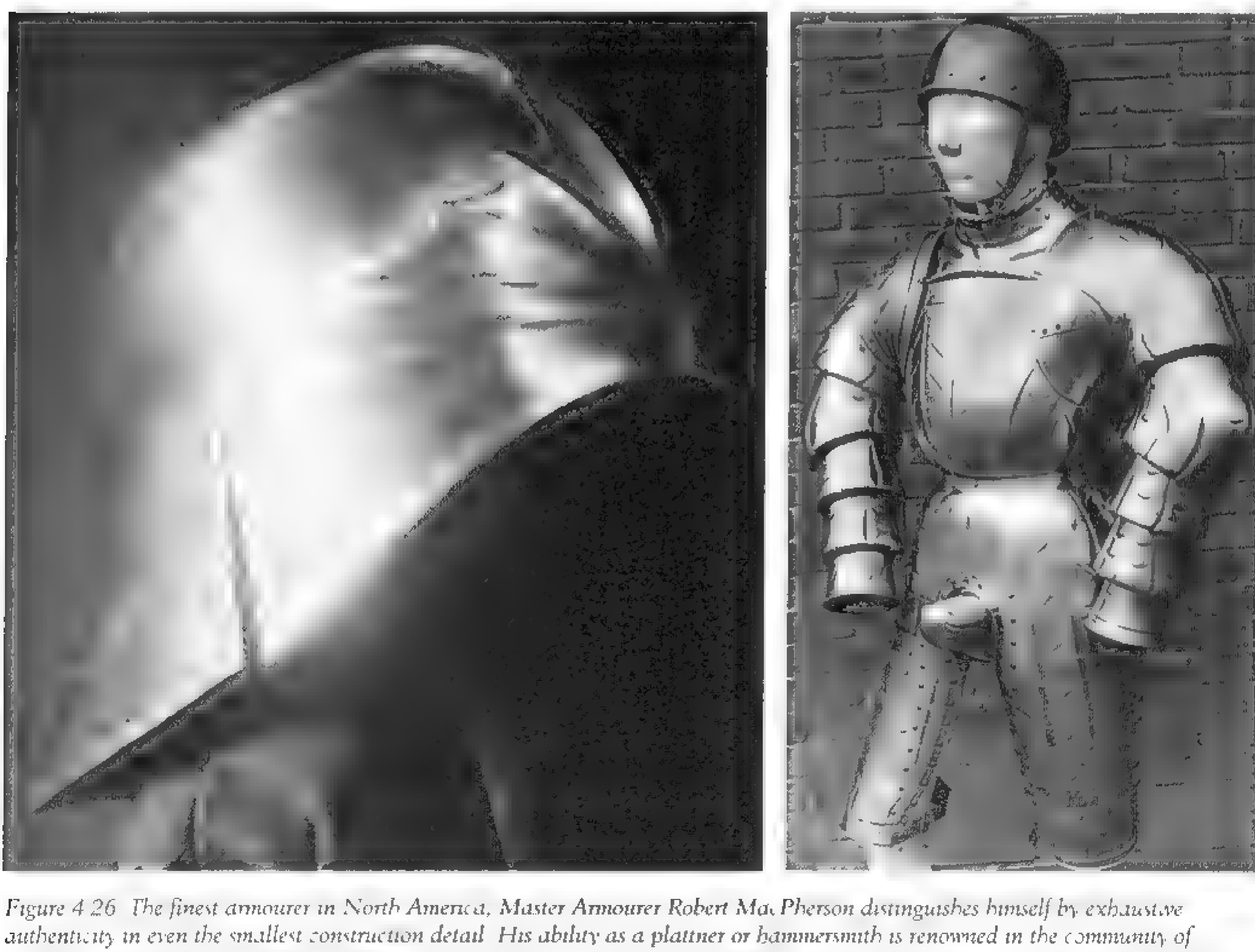


Figure 4.26 The finest armourer in North America, Master Armourer Robert MacPherson distinguishes himself by exhaustive authenticity in even the smallest construction detail. His ability as a plattner or hammersmith is renowned in the community of armourers. The sallet above was actually a first attempt (it was raised in one piece) by Marianne Hansen, his wife, while the puffed and slashed armour at right stands as testimony to his own skills. His work may also be seen in Figures 4.1, 4.27, 21.1, and 25.15

reproductions in the world. Mr. Radford works exclusively with medieval technique, arguing that the true essence of medieval pieces cannot be captured through modern means. His sincerity and skill come through cleanly in every piece he produces, a testament to what an armourer can achieve in this day and age, more than 400 years since the craft flourished and died.

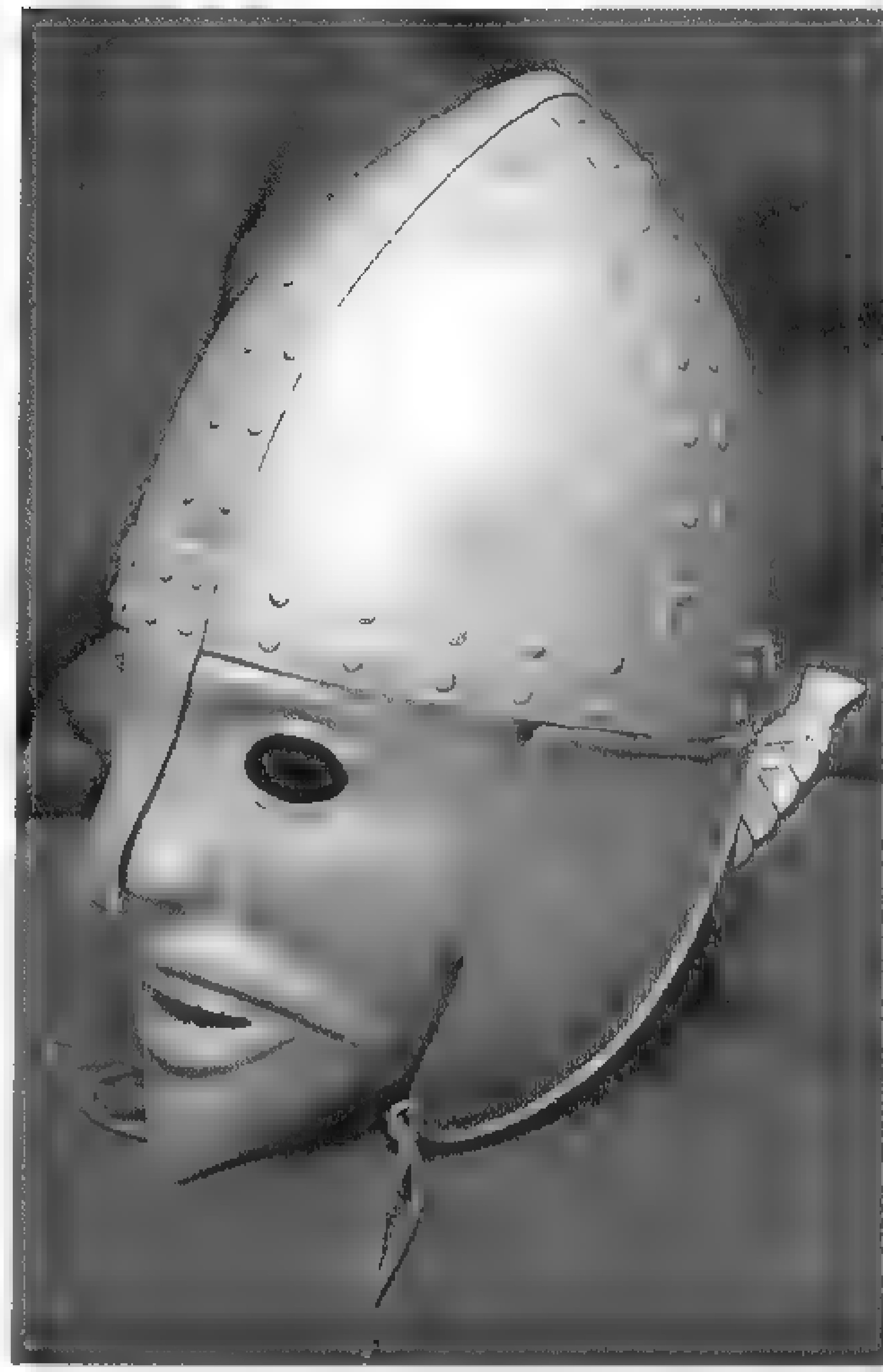


Figure 4 27. While he does produce exceptional reproduction quality pieces, Robert MacPherson is also active in helping members of the reenactment community to create their field presence and solving problems of modern béhourd-style combats. The gauntlet above is an anachronistic mitten gauntlet designed to provide more protection for the fingers while maintaining a transitional line, while the helmet answers the need for a facial defense on a style that would have historically been open-faced.

ENDNOTES

1 Some very interesting new scholarship by Mr. Silvio Leydi is in the works concerning the Milanese armourers—the Negroli family of the latter 15th and 16th centuries in particular. For a preview of this upcoming work, see yet another example of the fine scholarship now being pursued, *Heroic Armour of the Italian Renaissance: Philippo Negroli and his Contemporaries*. Stuart W. Pyhrr and José A. Godoy, Metropolitan Museum of Art, 1998

2 Edge, David, and John Miles Paddock. *Arms and Armour of the Medieval Knight*, Crescent, 1988. This book is the best introduction on the subject and is well illustrated with primary source photographs.

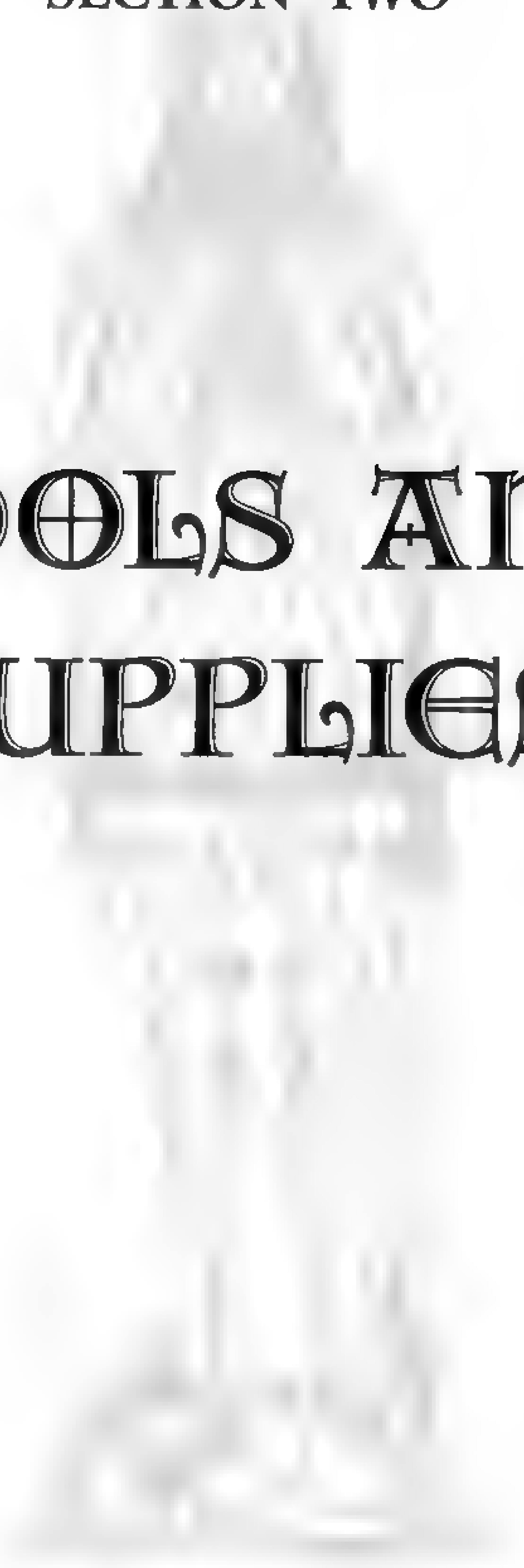
3 Scalini, Mario. *The Armoury of Castle Churburg, Vol. II*. This is a magnificent companion volume to the original work by Oswald Graf Trapp; excellent new scholarship in a beautifully produced edition.

4 Williams, Dr. Alan, and Anthony de Reuck. *The Royal Armouries at Greenwich, 1515–1649: Its History and Technology*. Royal Armouries Monograph #4.

5 Flax, Brian D., Ed. *Best of the Hammers, Vols 1–3* Raymond's Quiet Press, 1983–1985.

Figure 4.28. Although his work is difficult to locate Bill Radford creates pieces that are of exquisite craftsmanship nearly indistinguishable from the medieval originals If there is a "finest armourer in the world." the title probably belongs to this quiet, unassuming, yet exceptionally skilled armourer from England

SECTION TWO



TOOLS AND SUPPLIES

Figure 5.1 Armourers at work in the shop, from a late 15th century or early 16th century French manuscript. Note that the armourers work the metal hot, and in this case from the inside on the anvil, probably a rough doming operation. (Photo courtesy of Bibliotheque Nationale de France, Paris.)

Chapter

The Armourer's Workshop

The medieval armourer has left us tantalizingly few records of his working environment. From wills and inventories we know that some armourers ran businesses that spanned Europe, that they kept an inventory of tools and materials both in their primary workshops and in their homes, and that they possessed a great many hammers, stakes, and similar equipment.[1]

We know that many workshops sent their work out for final polishing and probably for grinding also. Polishing houses were powered, where possible, by waterwheels, necessitating their location next to an appropriate body of water. There are records granting armourers deeds to plots of land upon which such mills were to be built, but sadly none of the mills remain today.[2]

Alongside these references, we are fortunate to possess a number of manuscript illuminations that show armourers at work. Perhaps the most famous of these is the often reprinted "Maximilian's Workshop" (fig. 6.1), but there are a host of other sources—mostly German that show specific elements of the armourer's workshop.

Of particular value is the *Hausbuch der Mendelschen Zwolfbruderstiftung*. Different components of these illustrations, chronicling medieval craftsmen for more than 130 years, show armourers in a variety of periods,

offering incredible detail in terms of the tools and techniques used. Elements of the work appear throughout this book; they should be studied closely for their immense value in terms of detail and precision.

Modern armourers spend a good deal of time peering intently at the illuminated references, trying to divine the purpose of each tool carelessly scattered about the workshops featured in these illustrations. It is both fun and educational, sometimes leading to breakthroughs in understanding as a new tool speeds the production of a hitherto difficult step.

THE MODERN WORKSHOP

A modern armourer's workshop can be as simple as a section of a basement or a garage or as dedicated as a complete studio. I have seen some of the finest armour come out of a garage and some of the worst being produced in a "professional" workshop. A good workshop must have good light, sufficient ventilation, and be organized in such a way as to minimize the danger due to fire or dust hazards.

Noise

A primary concern will be the high level of noise created both by the obvious hammering phase but also by the hum of the buffing motor, sanders, music, and conversation that inevitably fills the air of an armourer's workshop.

I have never seen documentation discussing how—or if—medieval armourers protected their hearing from the incessant ringing, banging, and screeching that accompanies the

Figure 5.2 Most modern armourers' workshops lack the central forge of the medieval original, yet a good deal of work can be produced in a very compact space. This archive photograph of Theodore Monnich's workshop shows many of the main tools and, as usual, many projects in progress.

armourer's art. Perhaps they stuffed linen into their ears, or maybe beeswax. If so, such evidence has yet to surface.

There is a whole range of sound that must be insulated for the protection of the craftsmen and the comfort of those outside. Hammering is far and away the noisiest operation in the shop. Not only does the sound carry through the air but it also moves through the floor, especially if the floor is wood or concrete.

Whenever anyone is hammering, everyone in the workshop should wear hearing protection. The human ear is a delicate instrument, and a little discomfort is a worthwhile price to pay to keep your hearing. Two main options for hearing protection seem to work. The first are the foam inserts that are washable, disposable, and inexpensive. The foam is warmed with the fingers and then inserted into the ear's canal, where it expands to make a very effective seal. They are roughly \$.50 a set, can be thrown into the washer, and are available at most drug or hardware stores.

The second and most effective option are the commercial "earphone" style protectors available at most better hardware stores and at gun shows. These run anywhere from \$10 to \$50 a set, depending upon the quality.

Custom-made hearing protectors are another option. Cast to the individual's own aural canal, they are comfortable and

Figure 5 3. Protection of the ears is critical—the workshop abounds with noisemaking activities such as hammering and grinding

extremely effective. I have seen these sold for \$30 a set, but because they are custom-cast the individual must be present for a fitting. Such businesses can be found at gun shows, where they take orders and return the finished product by mail in a couple of weeks.

To insulate the shop to contain as much of the sound as possible, a common solution is distance. If the shop is conveniently located some distance from residences, complaints are less likely. Many regions have zoning laws that apply if you intend to armour as a business; be sure you are in compliance with your local regulations. Shops located in residential areas have the most trouble with noise insulation, so keep your neighbors in mind when hammering. In most cases there isn't much that can be done about the facilities that are available, but a little common sense and courtesy will go a long way.

There are several other ways to reduce the sound. Concrete or wooden floors can be covered, in limited places, with rubber matting or carpeting. In our commercial shop we created a "forming room" that was noiseproofed by raising the floor and insulating the walls with a special sort of foam.

Most of the sound is created by vibration of the heavy metal tools used for planishing and dishing. Years ago we discovered a sound-dampening coating used by fire engine companies to reduce the noise due to vibration on the inside panels of their trucks. This material, tradenamed "Aquaplas," substantially reduced the sound when painted on the side of our anvil and doming station.

Lighting

Light is an invaluable and often underestimated tool in any sort of forming or polishing operation. Take special care to insure the best lighting available for the cold-forming, polishing, and assembly areas. Shadows should be avoided, and the necessary wiring should be done such that cords do not cross work areas, power tools, or the welding area.

The medieval armourer probably solved this problem by situating his forming tools where sunlight could be used. In Figure 6.1,

Maximilian's main workbench is located just behind a large window that frames the whole illustration

Hot work done near the forge, by contrast, is better served with a dark setting, because the metal's color is critical to assessing its readiness for forming, annealing, or heat-treating. Consequently, forming work done hot should be located away from strong light.

Organization

For a single armourer, maintaining an organized workspace and distribution of tools is largely a matter of personal discipline. When more than one individual works in a shop, these considerations magnify greatly.

Generally, shop operations can be broken down into several regions, outlined in the chart at right. Sometimes there is little choice but to combine these areas into a very small space, such as a portion of a garage or basement. In this case, assiduous attention to cleanliness, order, and courtesy will help keep the smallest workshops from becoming a complete mess. A shop that is excessively cluttered invites carelessness and frustration when tools or project components cannot be located, and though workshop clutter is clearly medieval (look at the tools scattered on the floor in the illuminations!), it can be frustrating to look for the only hammer capable of reaching a particular spot, only to find it days later in a pile of dust under the workbench.

Design Area

For the medieval armourer, most of the patterning was probably done on the pieces themselves, using dividers and chalk or lead to mark the metal. Much of the final shaping was probably done by grinding or filing rather than through precise layouts on the flat sheet. Evidence for this theory consists of a frequent quality of "imperfection" derived from hand-wrought work, a lack of remaining patterns (at least nothing that has been recognized as one), and the extraordinary rough quality of the inside of extant pieces, indicating that much grinding had been done on the surface. Why not on the edge too?

AREA	REQUIREMENTS
Design	Cleanliness (to protect books and drawings), space to spread references and patterns. Possibly a corkboard. "Shop copies" of books or appropriate references. Storage system, probably envelopes or files, for patterns.
Cutting	Space for maneuvering of steel sheet around the shear, roughly 4 to 6 feet around the tool is best. Keep sharp shavings swept up!
Forming	Soundproofing, good lighting, heavy work benches, forming stations, hammers, and stakes easily at hand.
Welding	Fireproofing, darkness (to see welds), space for welding rod and available stock, extra glasses (for guests), welding gloves. Distance from people to insure safety. Keep flammables away, especially paint, solvents, fabrics, wood dust, etc. If a forge is available, it must conform to local environmental and safety requirements.
Polishing	Good lighting, dust and noise control, sufficient clearance around tools, space for wheels, compound, and sanding mediums (belts or disks). Preferably this area is separate from the rest of the shop to keep dust levels down.
Assembly	Good lighting, organization of rivets, bolts, punches, drill bits, and other hardware elements. Work-bench space to keep individual pieces in order. Anvils, hammers, and clippers.
Storage	Shelf space and armour stands for in-progress projects. Places to store sheet steel and barstock.

Most modern armourers start their work from patterns. These patterns are refined and evolve over time as the armourer gains experience. They then may be passed on to students, where they are modified to meet the needs of differing tools and techniques.

The first step in the actual creation of an element of armour is its design. The eye must be trained before the metal is worked, and there should be a place in the armourer's workshop where such work can be done away from dust and clutter. Shop dust has a way of coating the workshop, so valuable reference books should never be brought into it.

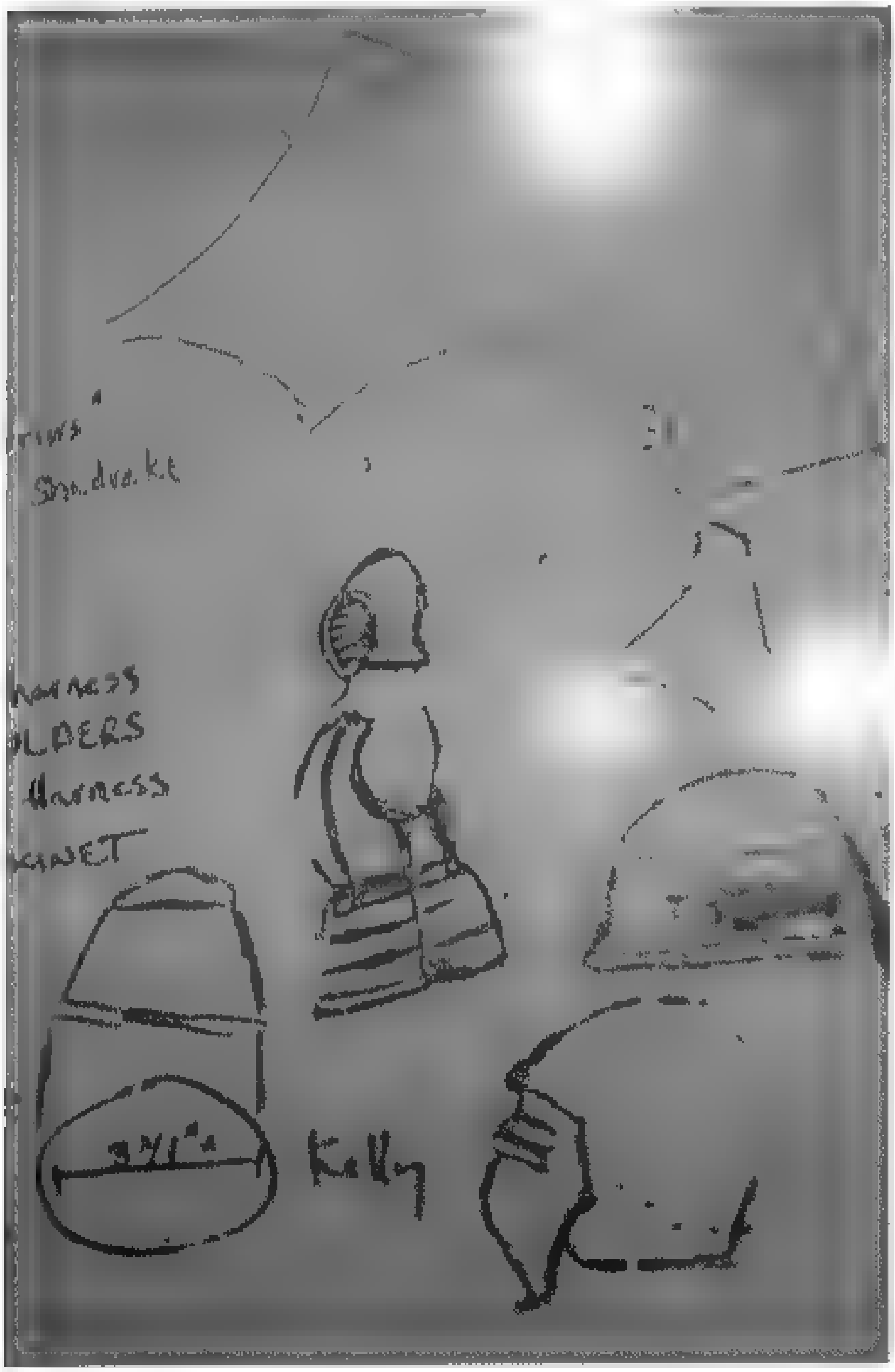


Figure 5.4 Training the armourer's eye is as important as is his skill with technique. This refinement is a gradual process, and the armourer should take care to surround his working area with as many good reference examples as possible. Copies of appropriate photographs are posted for easy reference at all stages of the creation process.

Photocopies of pertinent sections for working drawings should always be preferred, although a few of the most common references might be obtained in duplicate, one for the reference shelf and one for the workshop.

Often the design area is also the shop's main workbench. Files should be kept both for patterns and template material. Patterning materials such as permanent markers, chalk envelopes, file folders, and calipers should be kept together, preferably near the main bench but as far away from the dust as possible. Original photographs should never be brought into the shop directly but should be copied and posted to protect them from the incessant dust.

Prominently displayed around the workshop should be the full-sized drawings, reference photocopies, and the like. Corkboards, wooden posts, or other places for photocopies should be available near the forming and design areas so that the armourer can keep the shapes in mind during the most critical patterning and forming stages.

Cutting Area

Medieval armourers cut their metal either with huge shears that resembled giant scissors or with metal-cutting chisels. The shears were simply clamped in a vice, while the chisels can be seen scattered around the workbenches and floors.

The modern shop will likewise need someplace to cut sheet metal. The Beverly shear, the most common tool for the task, requires between 9 and 12 square feet of floor space. But most importantly, cutting creates thin, extremely sharp waste that can pierce shoes and feet. These curled scraps should be kept swept up to avoid painful injuries. As a matter of efficiency, the cutting area should not be too far from where the sheets of steel are to be kept.

Forming Areas

In any forming project, several stakes will be used in quick succession. It is best to have a variety of stake holders and vices arranged such that the positions can be changed to satisfy the needs of a particular project and the available

light. In our shop there are two forming benches and a leg vice that can be arranged in a kind of triangle so that all the armourer has to do is turn to reach another stake.

Anvils can be kept either on large tree stumps or stands. Small stumps are convenient for making shallow dishes (see fig. 6.37). Doming dishes can be attached to a bench, or cut-off welding tanks can be moved around the shop at will. We filled our dishing stump with sand and welded the bottom closed, reducing the sound and mass simultaneously.

Hammers should be kept in a rack or similar arrangement so that the faces can be quickly reviewed. (In smaller workshops, strips of leather are often wrapped along the edge of a workbench or around a stump to hold the hammers.) As with stakes, many hammers will likely be used on any given project. Finding the right hammer quickly saves time and reinforces good decisions—if the hammers are strewn about the shop and the best hammer for a given task isn't at hand, the armourer will likely settle for one that will not do as well. The work will suffer.

Hot Work/Welding/Heat-Treating

Much of the work of the armourer can be done hot, saving time and speeding the roughing of the piece by many times. Some illuminations show work being done hot, while in others the armourer works by holding the piece with his bare hand, a strong argument for cold working.[3] Medieval armourers seem to have worked in hooded and open forges, using traditional tongs to handle the piece as it was worked over various stakes. There is also some evidence that pieces were forge-welded together, and the central forge with a heavy anvil nearby serves admirably for such work.

Heat-treating methods were amongst the medieval armourer's greatest secrets. We have little direct evidence for how such work was done, though the main shop forge would certainly suffice.

In the illuminations, the forge is often on one wall, built into a stout chimney. Sometimes it is pictured in the center of the room, with arched openings on each side, and there is always one or more huge anvils nearby along with places to embed stakes for the larger raising or rough forming operations.

Modern armourers must still perform these same tasks, though far less work is done hot by the novice and intermediate. For a novice, an oxyacetylene torch will suffice as long as the armourer has a rosebud tip for it

Figure 5.5 It is exceptionally useful to have a variety of stakes available within a single work area so that the transaction time needed to switch between tools is reduced. Here in a portion of the author's workshop, the stake bench is mounted on heavy casters and rolled over to the hammer rack and leg vice so that several stakes and all of the hammers are immediately available.

Figure 5.6. A heavy leg vice is an excellent tool for securing stakes and holding work that dates back to the Middle Ages Blacksmiths still use them, and they can sometimes be found through the on-line auction houses

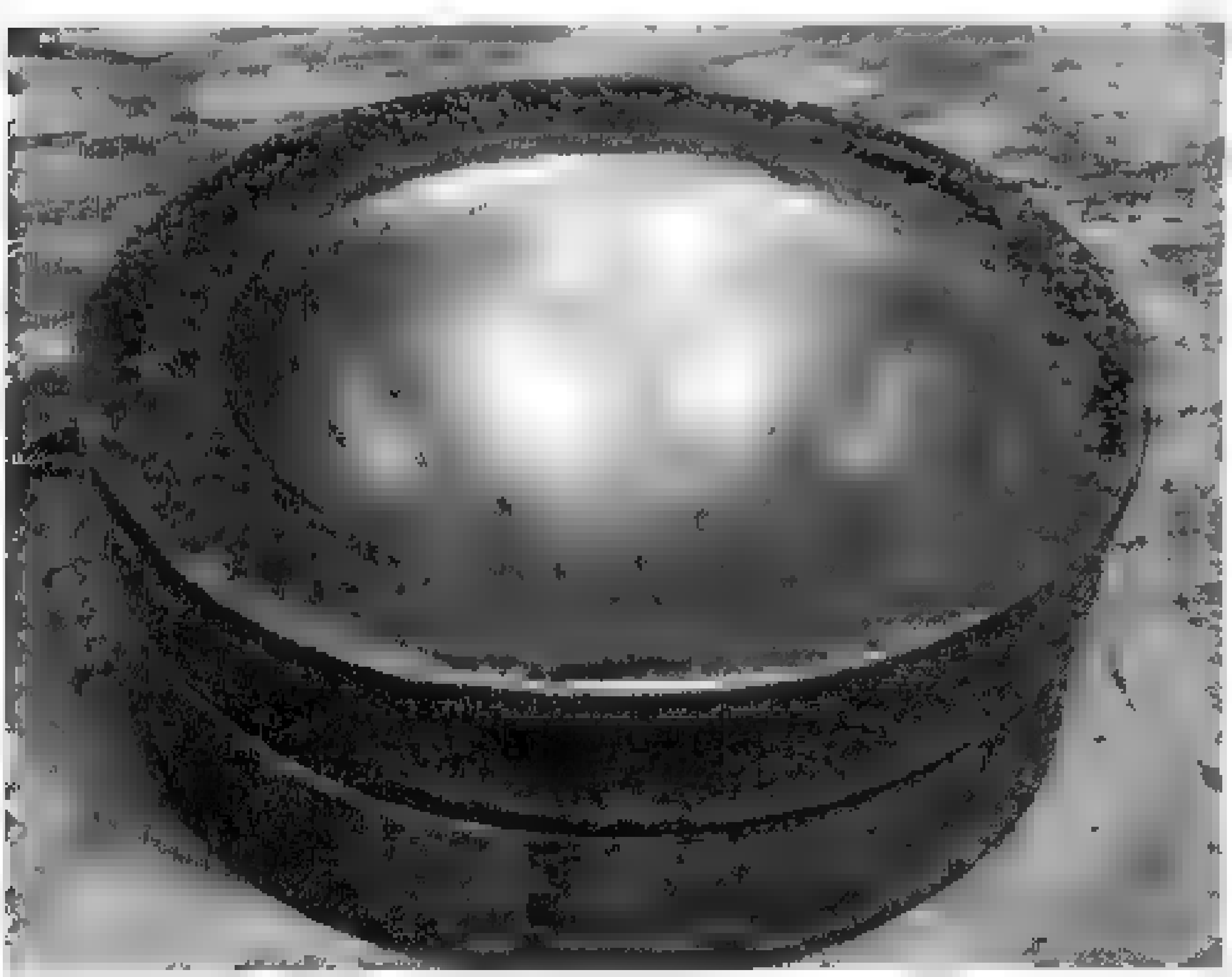


Figure 5 7 Aaron Toman suggested this innovative mounting technique to hold doming stakes in place A large bolt is welded to the base and the whole affair temporarily affixed to the bench with a huge nut They are easy to replace, and several can be available at any given time

and doesn't mind purchasing the oxygen and acetylene regularly.

Modern forges are still sometimes fired with coal, but the new propane models are often favored by intermediate and advanced armourers living in cities with restrictive air quality ordinances. These forges burn cleaner and are easier to start, and they are surprisingly cost effective. They can even be built from plans!

If a forge is installed, the appropriate safety precautions should be taken. The coke or propane fuel should be stored properly to reduce dust and the risk of accidental combustion. Ventilation is key, because the fumes and waves of heat from forge operations can overwhelm even the most stout individual. A quenching tank should be located in the immediate area, and at least one large anvil and vice must be available for hot work.

A novice armourer doesn't necessarily need to worry about a forge to get started. While an advanced armourer may well opt to use forge-welds to accomplish deep raising and to speed forming, the novice, intermediate, and most advanced armourers will still reach for a gas or combination gas/electric welder. Welding requires a bench that can withstand the heat of the torch, provide separation from combustibles, and protect people.

Welding tanks should be secured to the wall with a chain according to local code. The welding hose should be secured away from places where it could be damaged, such as near the metal rack or forming or polishing areas. They should be inspected periodically—acetylene "loose" in the shop could be a very dangerous thing.

With any heat source, use common sense. If your shop is in a garage or basement, use special care. Many volatile chemicals are found in the garage that present a substantial danger. Clothing, cardboard, old newspapers, aerosol cans, gas cans—these are only a few examples of combustibles that may lurk in dark corners.

The welding area should be away from the main working space. If other people are working too close to the welding area, they can bump the welder, exposing both to the risk of serious burns

Ideally, the welding table will be made of metal and topped with heat-tolerant material such as firebricks. These bricks are useful for stacking to hold pieces for welding. A metal bench at a comfortable height should be nearby so that the welder doesn't have to slouch or stretch to be in proper position. Supplies of welding rod, flux, tip cleaners, and tips should be within reach.

Polishing

Medieval polishing was accomplished over large wheels powered by water-driven mills. In some cases workshops may have been fitted with such facilities, but in many others the mills were separate establishments. Most modern armourers do not share the medieval luxury of sending their rough work out to be finished. (I have in the past been fortunate enough to have had a talented apprentice who fulfilled this role, and it was a glorious thing!)

The modern armourer can of course harness electricity rather than water to turn his wheel, polishing the work himself or handing it off to a specialty polishing shop. Because of the expense and time delay, most do the work themselves. He can isolate the grinding/polishing operations in a separate room, he can invest in a powerful air circulation system, or he can put up with the dust inherent in the work.

It is perhaps ironic that the armour's beauty rises out of the dirtiest area of the shop, the dusty and grimy polishing area. Approximately half of the time to complete a piece is invested in finishing, so it is likely that the polishing area will be in use far more often than all the rest of the stations combined.

Sanding and polishing create millions of particles, so dust control can be a serious problem. Novices can address this issue by cleaning up after each session, working carefully with a brush and broom in attempt to remove as much as possible from the work area. Intermediate armourers often want a more decisive control, sometimes opting for a separate buffing/sanding area.

Dust control systems are available from commercial vendors and are highly recommended if a good amount of work is done. Dust masks, such as those available from hardware stores or occupational safety supply companies, will help address the dust somewhat, which at best is a nuisance and at worst a potential health hazard.

Assembly

The main workbench is often where the assembly of the pieces is done, so small anvils, T-stakes, and an ample supply of measuring devices, bolts, and marking supplies should be

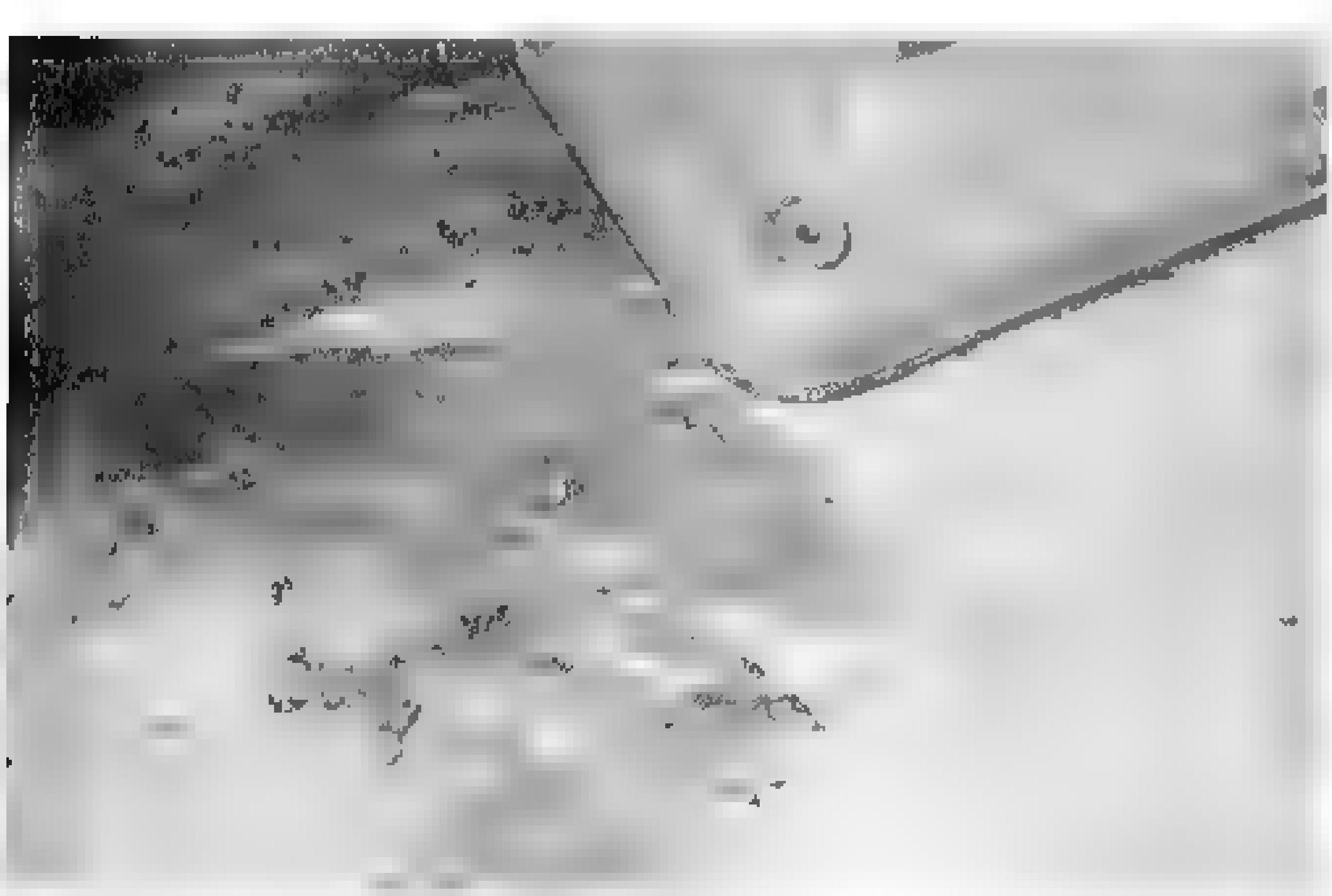


Figure 5.8. Grinding and polishing represent fully half the time put into a finished piece of armour. It is where the piece's beauty finally begins to emerge, yet it is also the grimiest area of the shop. Judicious cleaning or a powerful dust control system is necessary to manage the dust, and this should be taken seriously, since this kind of dust can be a serious health hazard.

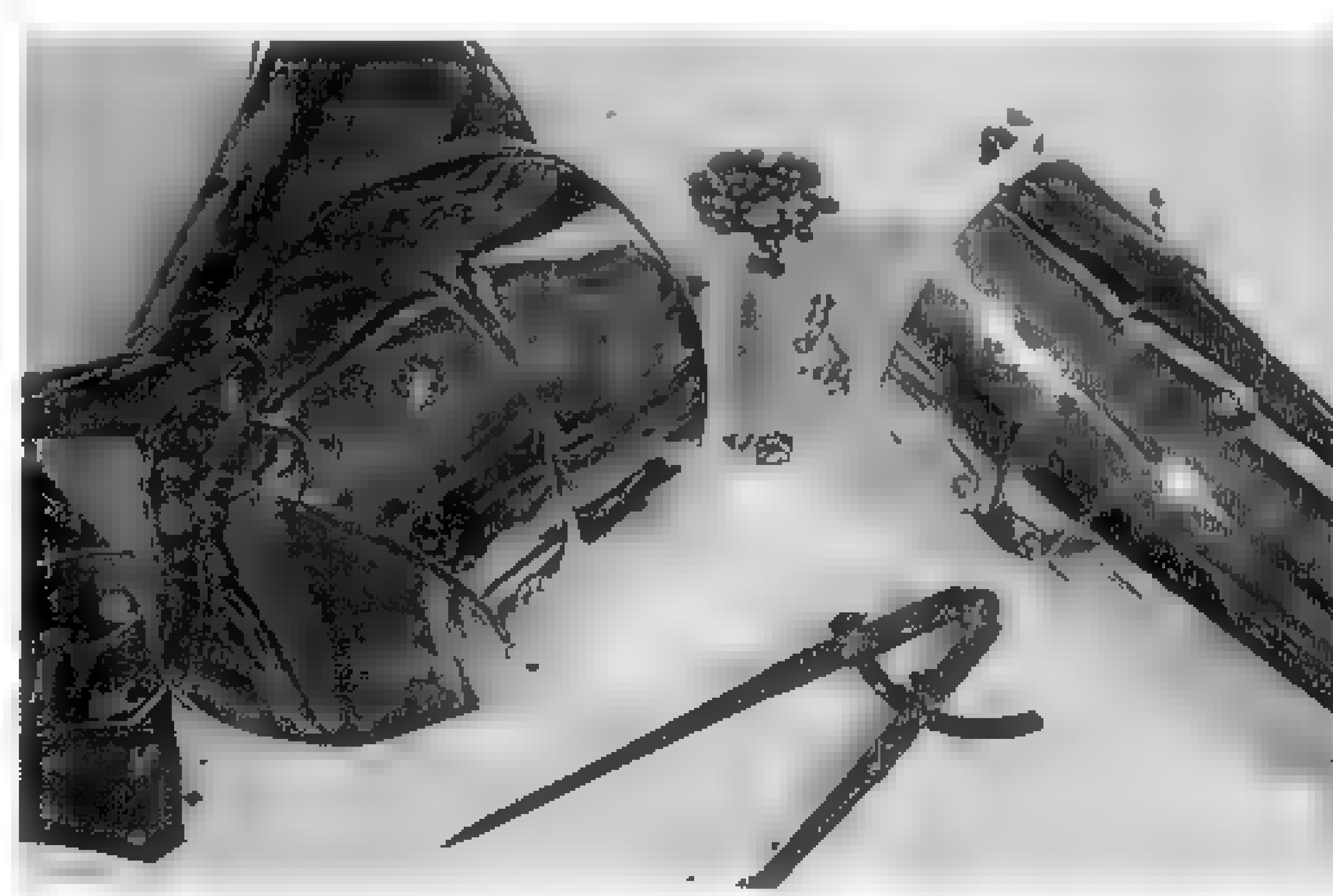


Figure 5.9. Good lighting, a clear area to work, and a supply of punches, marking rods, nuts, bolts, and rivets should all be within easy reach of the assembly area.

handy. In most cases this area is mixed with the patterning/research area, which is convenient since the pictures needed for patterning are also useful in the assembly and detailing phase.

Storage

Every workshop creates a multitude of unfinished pieces, and these are stored most efficiently on shelves. Production shops usually have racks and hanging pins for pieces so that they serve simultaneously as decoration and out-of-the-way storage.

Power

As has already been mentioned, medieval workshops used water to power grinding wheels and, at least as early as the 17th century, power hammers.

Modern armourers require power for lights, drills, grinding machines, and polishers. All this adds up to a great deal of amperage, so the armourer should use care not to overtax the available wiring. Balancing power over several circuits will help, and the intermediate or advanced armourer will often want to have an electrician run outlets near the main workbench.

Other Safety Considerations

Safety must be the armourer's responsibility, both for himself and for students and visitors to the workshop. Take appropriate safety precautions with any tool or material, particularly with dangerous substances such as acids, fumes, or dust.

Appropriate fire extinguishers should be available, charged, and current. Electrical cords should be out of the way and should not be run near areas where the sharp edges of sheet metal or tools can cut soft wire insulation.

Tool guards are often effective, so use them where appropriate. Eye and ear protection should be worn at all times, and extra sets of glasses, work gloves, and hearing protection should be kept for anyone who might be in the workshop, not just for those actively working on projects. Dust masks should be worn during grinding and polishing.

With just a few safety precautions in mind, an armourer's workshop can be fitted into a single car garage or even a fraction of that space. When I began, my first workshop was the floor of my apartment, providing enough space for a very small selection of tools exclusively for making the small plates required for gauntlets. Novice armourers might well be fortunate enough to find a semi-local workshop where they can hone their skills while they build up the collection of tools they will need to work on their own.

An armourer is forever accumulating a large selection of tools, steels, rivets and other hardware, and research materials. Unfinished projects and forming experiments tend to gradually fill any space, transforming it from a mere garage to someplace that would have been familiar, if not precisely correct, to a medieval armourer.

ENDNOTES

1 Dobson, Christopher. "The Will of an Italian Armourer," unpublished paper given at the Wallace Collection Study Day, December 1998. The will is a very interesting document because it lists a good deal of tools but also a "whole armourers workshop." My own supposition is that some elements were stored at home and that these were likely extra or surplus pieces, or finished products waiting sale.

2 Pfaffenbichler, Matthias. *Armourers*, p. 55, for one of several examples.

3 Among those sources showing work being done hot with tongs, see the famous illumination in Hartman von Starkenberg (14th century), another in the Aeneid of Heinrich von Waldec (13th century), and MS Fr 1537 f 44 (15th century) in the Bibliotheque Nationale Contrast this with other instances where the work is clearly being done cold, as in some of the scenes from the *Hausbuch der Mendelschen Zwölfbrüderstiftung* (1533), *Minerva Visiting a Workshop* in Guillaume Vreland's grisaille, the armourer pictured in Jost Amman's *Stande und Handwerker* (1590s), and the illustration of Maximilian's armourers (fig 6.1 in this book) I tend to believe that work was done both hot and cold; roughed hot, smoothed cold, and heated for heat treating.

Figure 6.1 Medieval illustrations of the armourer's workshop are rare, but the most commonly reprinted is the 16th-century illustration of Maximilian's armourers by Hans Burgkmair. The emperor himself is depicted behind the lead armourer specifying how the work should be done. All of the elements required in an armourer's workshop are pictured: places to plan, cut, work, temper, polish, and assemble the pieces. Try to identify all the little tools scattered about the workshop.

Chapter

Tools

Nothing is as important to an armourer as his tools. While a sufficient set of tools takes years to accumulate, the novice armourer can begin work with just a few.

MARKING, MEASURING, AND PATTERN MAKING

Before any work can be done, the piece must be envisioned, patterned, and planned. As the project progresses, measuring and careful alignment are critical for success. The tools used for this process have changed little since the Middle Ages, though technological innovation has made some of the processes easier.

For Marking on Steel

The medieval armourer used chalk, and probably strips or "quills" of lead (*chalami di piombo*), to mark his material. Chalk and lead were readily available substances, and the health effects of lead were unknown then. Chalk is difficult to use with any degree of precision, and it tends to flake off with the application of heat Lead does not flake off but has the disadvantage of being toxic.

1999-2000 PRICES

Operation	Minimum Tools for the Novice Armourer	Price New	Price Used
Workshop	Medium bench vice	$50	$20–$40
Cutting	Jigsaw w/metal cutting blades	$75	$40
Forming	Ball-pien hammers, several sizes	$15 ea.	$1–$5 ea.
Forming	Basic raising hammer	$35	$25
Forming	Small hand sledge for miscellaneous operations	$10	$1–$5
Forming	Large wooden stump	$10	n/a
Forming	Section of railroad rail and/or an anvil @ 175 lbs.	Anvil-$550	Anvil-$1/lb RR rail-$20
Forming	First ball stake, 3″ diameter	$50	n/a
Punching	Medium-duty electric drill	$125	$50
Finishing	Metal files, 2 minimum	$15 ea.	$.50–$5 ea.
Finishing	Mounted electric motor, 3/4 hp minimum	$100	$25–$50
Finishing	Aluminum oxide sanding disks, 7″	$2.50 ea.	n/a
Finishing	Buffing wheel & compound	$35	n/a
Finishing	Floor wax	$5	n/a

Operation	Tools for the Intermediate Armourer	Price New	Price Used
Workshop	One or more leg vices	$250	$25–$150
Workshop	Buffing area with dust collection	$1000	n/a
Workshop	Forge, gas or coal	$200–$5000	$100–?
Cutting	Beverly or electric shear	$550	$300
Cutting	Good quality clippers, possibly Crescent brand	$40	$10
Forming	Scrap hammers and handles, all kinds, for single-purpose modification	n/a	$1–$10 ea.
Forming	Rawhide hammer, 3 lb., and others if possible	$35 ea.	$5–$10
Forming	Raising hammers, as available	$35 ea.	$5–$35
Forming	Finishing hammers, as available	$35 ea.	$5–$35
Forming	Stake plate	$375	$125
Forming	Dishing stake (cut-off welding cylinder possibly)	$50	n/a
Forming	Doming sandbag	$15–$20	n/a
Forming	Anvil, 175–300 lbs., with good edges & horn	$2.50–$4/lb.	$1–$2/lb.
Forming	Sections of railroad rail, lengths from 1″ to 12″, for tools	n/a	$.25–$.50/lb.
Forming	Bichorn or other bending stake	$300	$45–$150
Forming	Complete set of ball stakes, 1–5 1/2″	$400–$600	n/a
Forming	One or more creasing stakes	$30–$75 ea.	n/a
Punching	"Whitney" punch # 5 ("Jr." punch)	$65	$15
Punching	Larger metal punch for heavy steels	$275	$75
Joining	Lead block, 3–20 lbs.	$10–$30	n/a
Joining	Oxyacetylene welding w/variety of tips	$325–$500	$125
Finishing	Large selection of metal files for use & tool stock	$10 ea.	$.50–$5
Finishing	Knife maker's flexible-back belt sander	$1200	$900
Finishing	Mounted electric motor, 2 hp optimal	$300	$25–$200
Finishing	Buffing wheels & compound	$100–$200	n/a
Finishing	Microcrystalline wax	$24	n/a

Today, most armourers use highly durable felt tip markers for marking on steel. These indelible black markers are resistant to unintentional removal. With "Sharpies" you can draw directly on the project, and the lines will even resist mild heating. Find Sharpies or their equivalent in any office supply or department store. Keep a large supply on hand, because they have a tendency to disappear.

Pattern Stock

No medieval patterns remain, but it is likely that medieval armourers used simple measurements and a calibrated eye to cut rough shapes in the iron sheet, then trimmed and ground the piece to its final shape.

For modern armourers, who usually draft more precise patterns, symmetry is often important. For this reason, standard commercial file folders are ideal. They are semi-rigid, easily cut and taped together with masking tape for modifications, inexpensive and easy to obtain (used folders are often thrown out at offices), and, best of all, feature a strong central ridge around which half of the pattern can be drawn, cut, and opened to reveal a perfectly symmetrical pattern. Notes can be written directly on the pattern, along with the date, to maintain a permanent knowledge base useful years down the line when you haul out a pattern that hasn't been touched in a long time. Patterns should be stored in individual envelopes identifying the project and date and containing all parts or notes for the project. Manila 8 1/2 x 11-inch envelopes are ideal for this purpose.

In order to test for symmetry, measure rounded surfaces, and take accurate measurements, large calipers (fig. 6.3) are extremely useful. They can be obtained at hardware stores and sculpture supply houses or made at home. Medieval craftsmen of all sorts used both the curved and straight varieties to test their work, as is evident from remaining woodcuts.

CUTTING TOOLS

Medieval shears seem to have been large, straight tools that were clamped into a vice or clamp sunk into a stump. These shears would have been used to snip small, straight sections of metal, which would then have been filed or ground into smooth curves. The shape of these shears is consistent from the 14th through the 17th centuries.

Modern armour projects are greatly speeded along by the use of a throatless "Beverly" shear (fig. 6.7). While metal can be cut with modern jigsaws, band saws, torches, or plasma cutters, a shear is faster and more adaptable, not to mention the correct medieval solution.

Every project will require cutting at the start and trimming as it progresses, though

Figure 6.2. Lead and chalk were used by medieval armourers for marking on steel, and they still can be used today. Permanent markers are a useful alternative

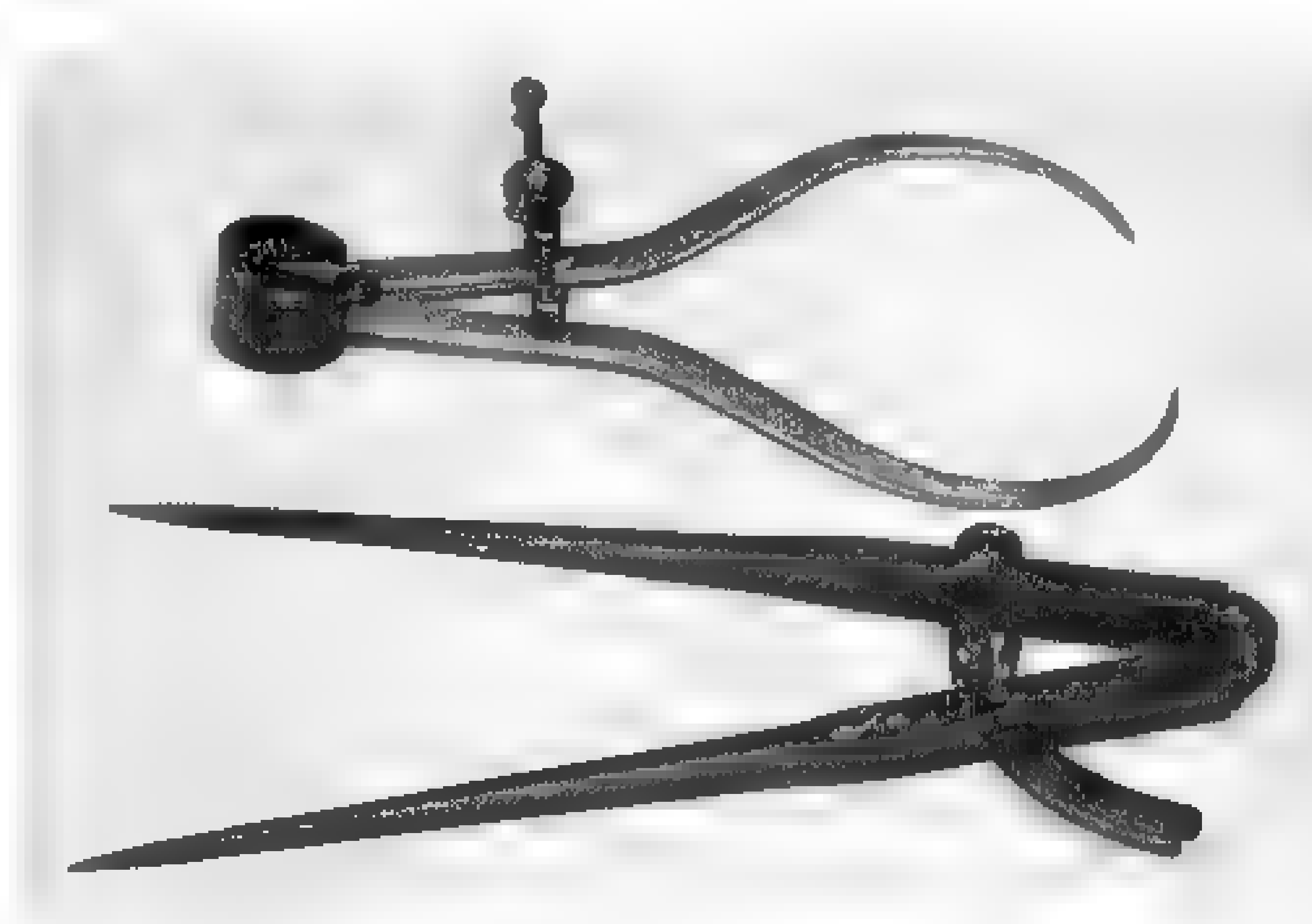


Figure 6.3. Two of the more important tools to the armourer are basic calipers and dividers. These are used to measure clients and help with symmetry, not to mention even spacing of rivets and holes

Figure 6.4. This spectacular shear is from the Greenwich Armouries founded by Henry VIII preserved in the collection of the Royal Armouries workshops. (Photo © Board of Trustees of the Royal Armouries.)

Figure 6.5 This shear was purchased through an on-line auction house for a very reasonable price It is approximately 20 inches in length and can cut 16 gauge steel with little trouble.

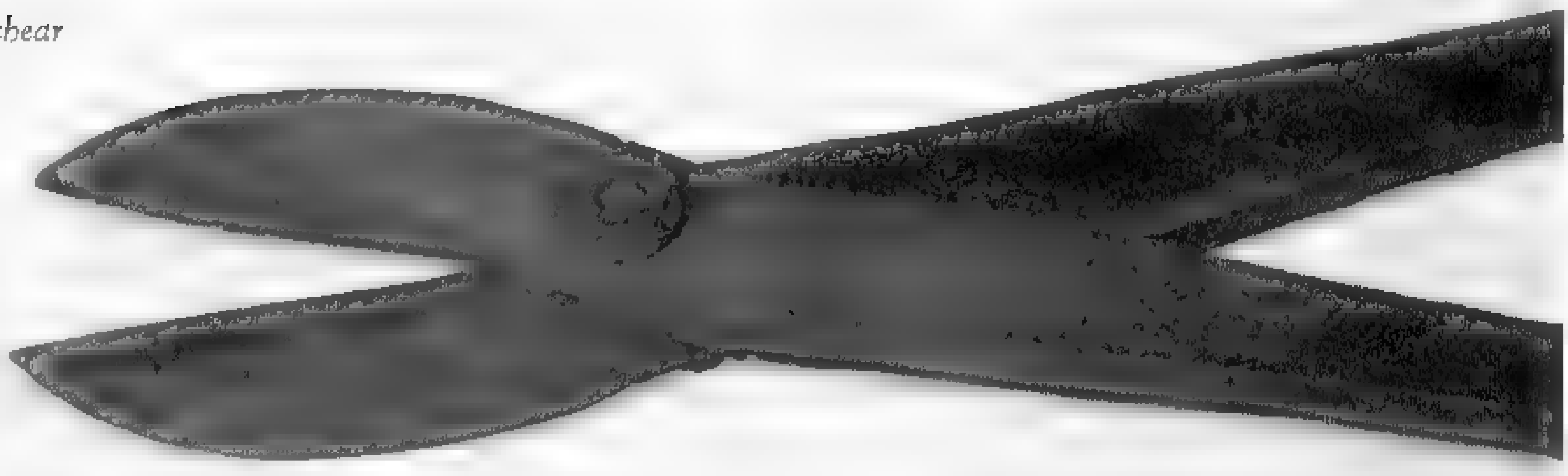


Figure 6 6. Neither jigsaws nor hand shears are ideal for cutting metal used for armour reproductions. Hand shears will not cut thick-enough material. Jigsaws will work, but they cut very slowly.

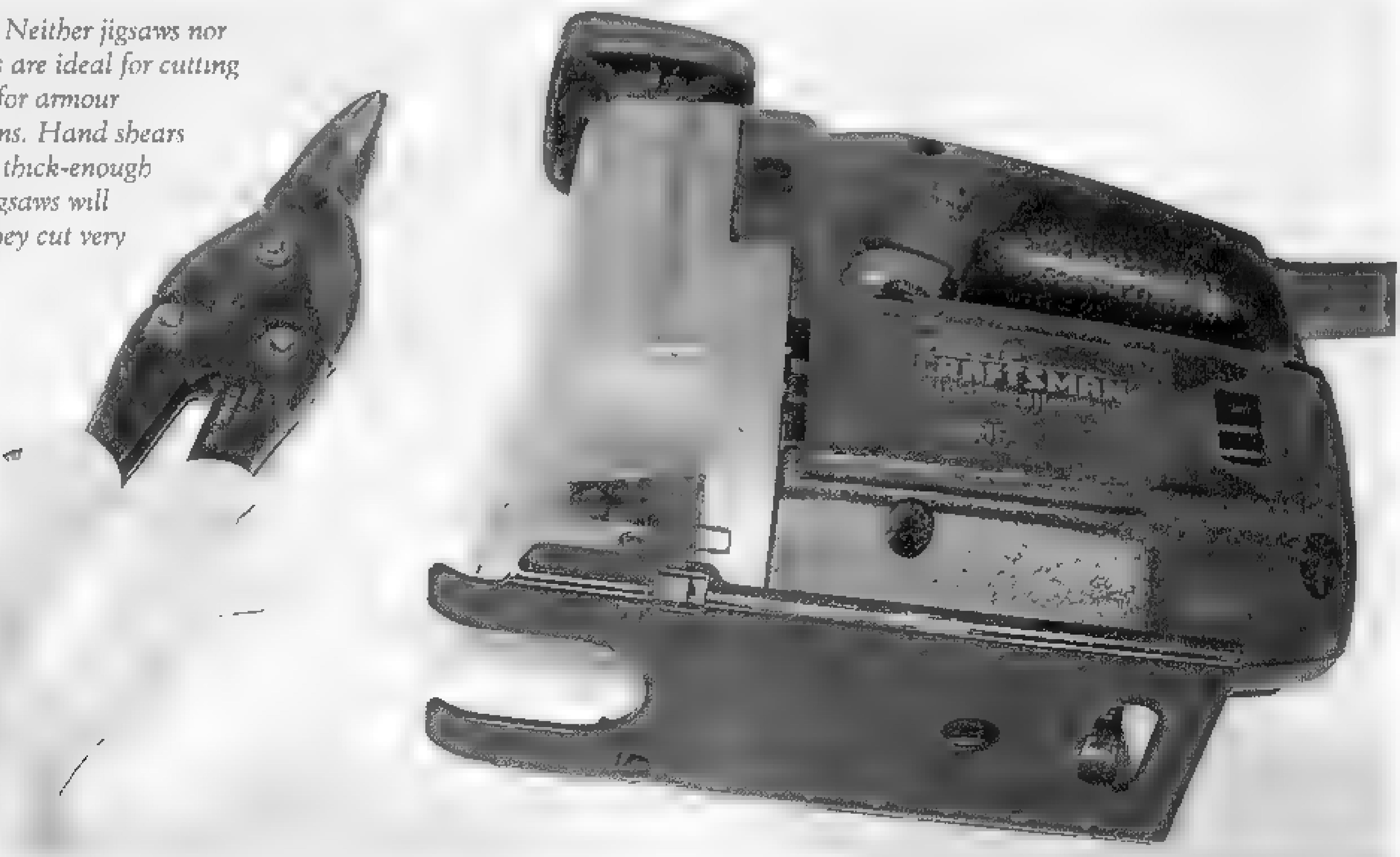


Figure 6.7 While the medieval armourer used a straight shear to cut metal the modern armourer has the luxury of an important innovation, the "throatless" shear made by Beverly Manufacturing of Chicago, Illinois The shear cuts very small radius curves and straight lines with equal ease and is relatively safe, quiet, and easy to handle.

modern armourers tend to cut precise patterns, minimizing the necessary trim or edge grinding. As the armourer progresses in skill, however, less reliance will be placed on the initial pattern, and more of the shape will emerge from the hammered form rather than from a copied pattern. That said, the armourer will still cut a great deal of sheet steel in the workshop, and the shear is the fastest solution.

Jigsaws

Although definitely not a preferred solution for the problem of cutting metal, brand new armourers will often end up with jigsaws as their only solution. Most home jigsaws are too light for work on regular sheet metal in the thickness used for tournament reenactments, but some limited use can be had from them. In order to cut with a jigsaw, first be sure you have metal-cutting jigsaw blades of the right size and that the work is clamped firmly into place, as it will vibrate a good deal.

Used jigsaws may be found in pawnshops and used tool houses and at auction. They are very common and inexpensive. If you are intent on purchasing a new one, buy a heavy-duty model.

Hand Shears

The medieval *paia di lanciatoi da maglie* or "peyre of sherys" has not changed much. Modern hand shears or snips are generally too light for work on armour. They can be used with limited effect on nonferrous metals, even though medieval armourers seem to have used very large shears for their rough work. Fortunately, we have a technological advance that makes the large straight shear obsolete. Power shears will cut metal up to 14 gauge in thickness, but they are expensive, and the throatless shear described below is both faster and more precise.

Beverly Shears

The medieval "strong" shear (or Italian *ciosoie da tagliere*) was used for cutting thicker material. By far and away the most effective tool for cutting sheet steel is the Beverly shear made by the Beverly Manufacturing Company

of Chicago, Illinois. The shears have remained in constant use, unchanged for many years. These are also called "throatless" shears because they can cut heavy steels in either direction with ease and at a very fine level of control.

Beverly makes three models of throatless shear: the B1, B2 and B3. The B1 is rated to 18 gauge mild steel but is really too light for most armouring work. The B3 features a heavy ball bearing to hold heavy stock in place and is rated to 10 gauge stainless steel; it is a bit too large for much of the armourer's work. The B2 is the right choice.

The Beverly B2 shear can cut steel up to nearly 1/8 inch (12 gauge) with ease so long as the blades are adjusted properly. The blades should be adjusted to a range of 10 to 25 percent of the material's thickness for optimal performance. Adjustments are done by working an Allen wrench to align the blades; instructions are provided with every shear sold. In my shop the Allen wrench is tied to the stand so that it is always available.

Beverly shears should be mounted on some sort of solid pedestal so that the shear will not move when cutting. A small table can be used provided that it is not used for anything else; enough room must be left around the shear for the movement of large sheets of steel.

When a shear cuts, slivers of steel curl up and collect around its base. These should always be swept up immediately because they have a tendency to rip into shoes, tires, and flesh. The unwary might well step on part of a sliver and drive it with force into the foot, so heavy shoes should always be worn to avoid injury. Sharp corners remaining on the steel when pieces are cut out are also dangerous—they should be trimmed.

The first expensive tool you purchase for a new armoury should be a Beverly shear. It will pay for itself many times as you cut pieces with ease and precision. New shears have the virtue of a known quality of blade and chassis, but they are roughly double the price of a used pair. Even used Beverlys are rare and should always be purchased if available, since there are many armourers who would quickly add one or more to their shop if the price was right.

HAMMERS

Should you have the fortune to visit the workshop of a practicing armourer, you will find one or more racks of hammers, each specialized for a particular operation. This daunting collection takes years to accumulate, but fortunately many of the basic hammers are either available in the retail market or can be modified from commonly available styles.

Although every armourer I have met develops a preference for a *single* hammer,

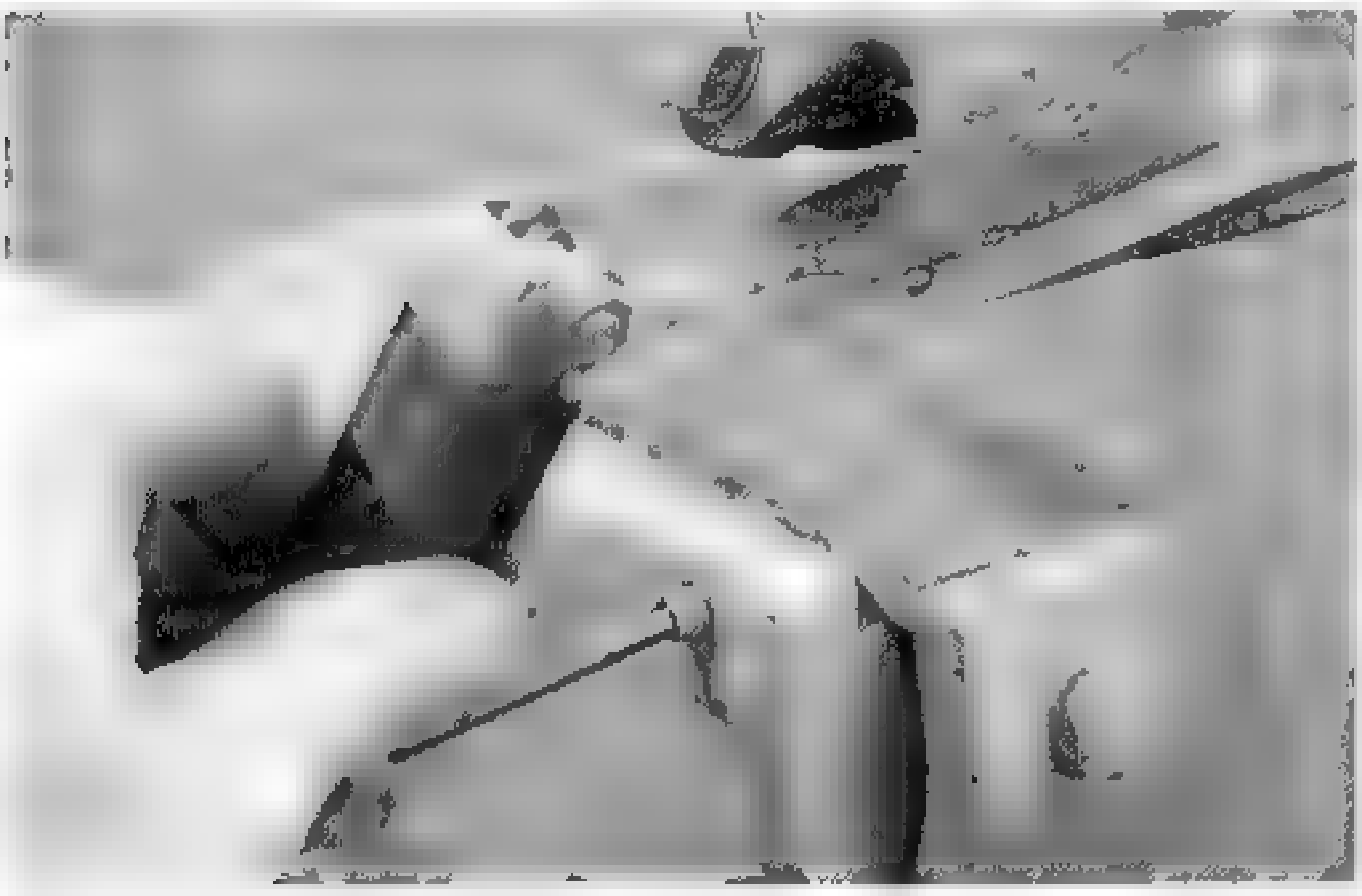


Figure 6.8 To cut effectively, the gap between the blades should be adjusted correctly. As a rule of thumb, the gap should be approximately 10 to 25 percent of the thickness of the material to be cut

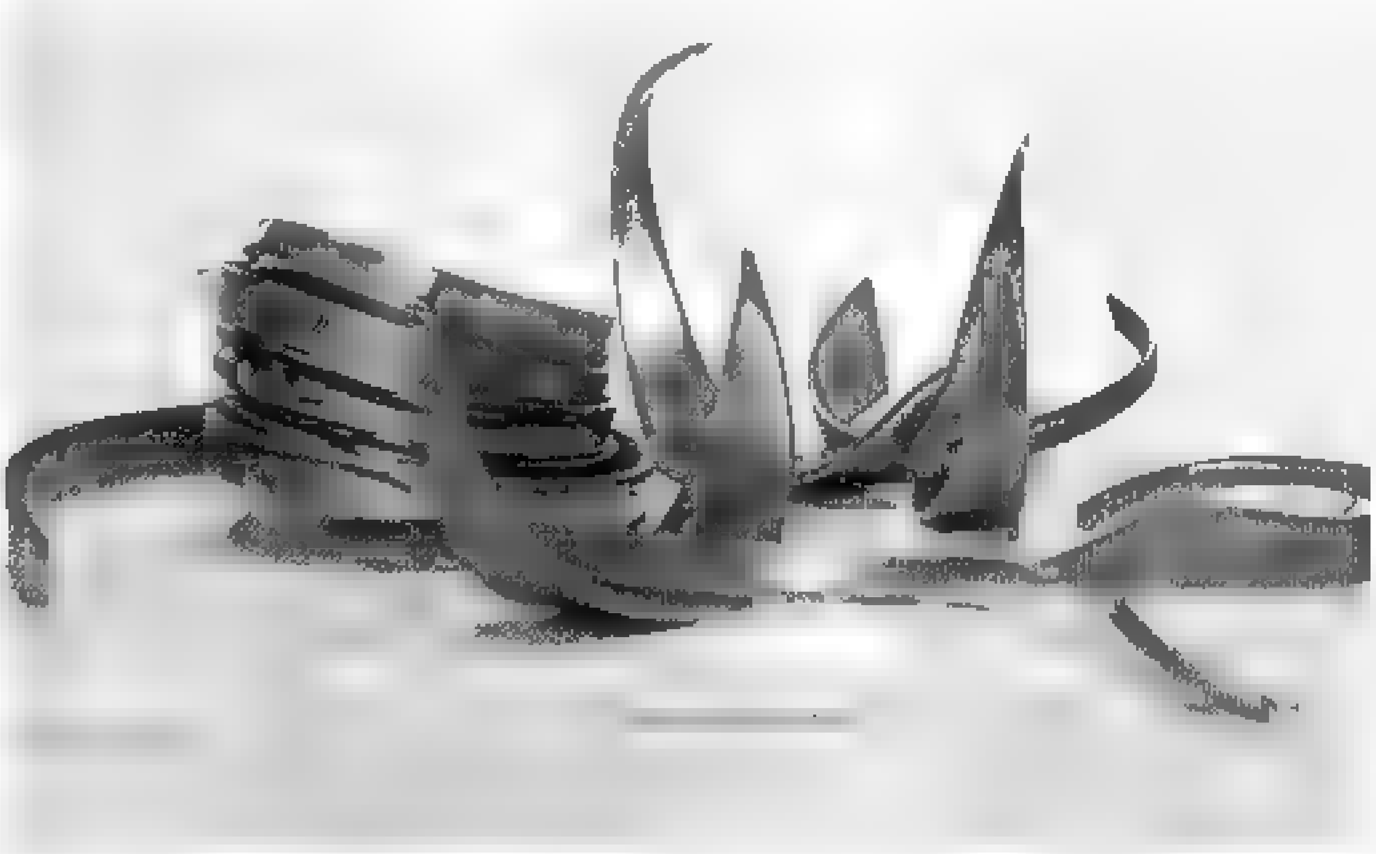


Figure 6.9 The slivers above are typical of the scrap produced by the Beverly shear. These pieces are sharp and must be policed to ensure they aren't stepped on — with a man's mass, they can pass through the shoe and deep into the foot, not to mention the danger to tires

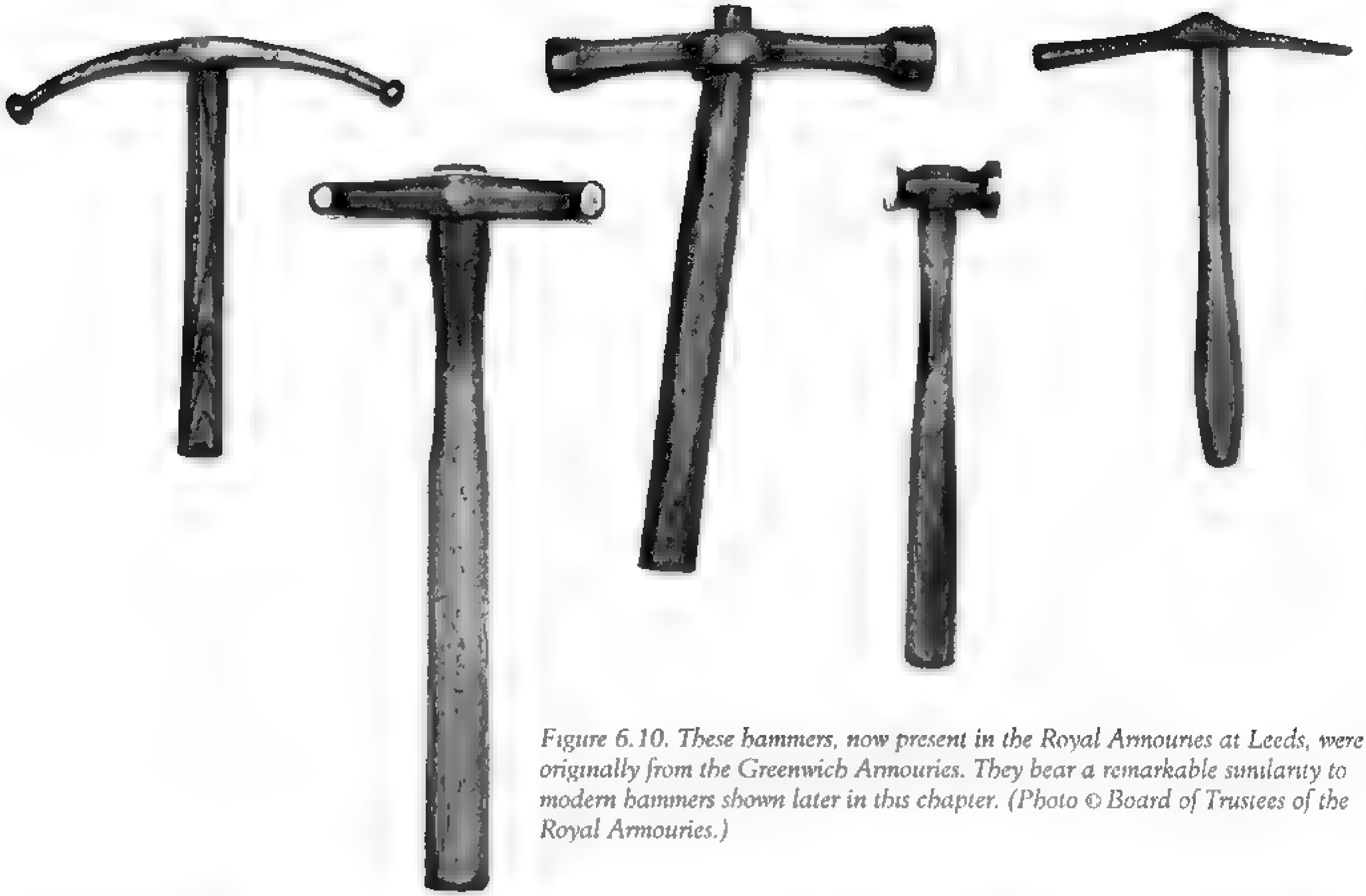


Figure 6.10. These hammers, now present in the Royal Armouries at Leeds, were originally from the Greenwich Armouries. They bear a remarkable similarity to modern hammers shown later in this chapter. (Photo © Board of Trustees of the Royal Armouries.)

Figure 6.11. Soft-faced hammers are very useful in that they can form without scoring or gouging. The hammers above have replaceable rawhide faces weighted by the hammerhead. The solid leather mallet is excellent for simple bends in light or medium stock

several are required to conduct even the most basic work. Hammers are used to roughly form the piece; to refine it; to add details such as creasing, fluting, and embossing; to roll the edges; and finally, to smooth and harden it in preparation for polishing.

Below are the four basic families of hammers for the armourer's art:

Rawhides and Other Soft-Faced Hammers

It is possible, though as yet undocumented, that medieval armourers used wooden, copper, or brass hammers for different tasks. Although not all modern armourers use weighted rawhide hammers, they are invaluable. Most armourers use weighted hammers that employ rawhide plugs held in place by a two-part attachment that can be untightened so the faces can be replaced. Large wooden and smaller copper hammers have also been used for light forming without scoring. An unweighted rawhide in the 1 pound range is ideal for simple bends.

Doming Hammers

Doming hammers have a partially spherical face used for pushing metal out, a set of techniques called "doming" or, popularly, "dishing." The domed face of the hammer is used to stretch the metal, usually into a form of metal or wood or into a leather-covered sandbag. Doming hammers are almost never used on the outside of the metal on account of the craterlike depressions they tend to leave behind. However, the arc on the dome can range from very pronounced, as it is on a ball-pien hammer, to a very subtle curve nearly indistinguishable from a flat face. The striking surface on a doming hammer is usually round to prevent the striking of a corner into the metal, although a square face is occasionally useful.

Raising Hammers

Also called a "cross-pien," the raising hammer is used primarily to work the metal from the outside, compressing it over a stake. The head of a raising hammer is oval or rectangular, a section of a cylinder, or a parabola rather than a

Figure 6.12. The replaceable rawhide keeps the hammer from scoring the work, while the mass provided by the steel casing gives the armourer a potent option for doming without marking the metal

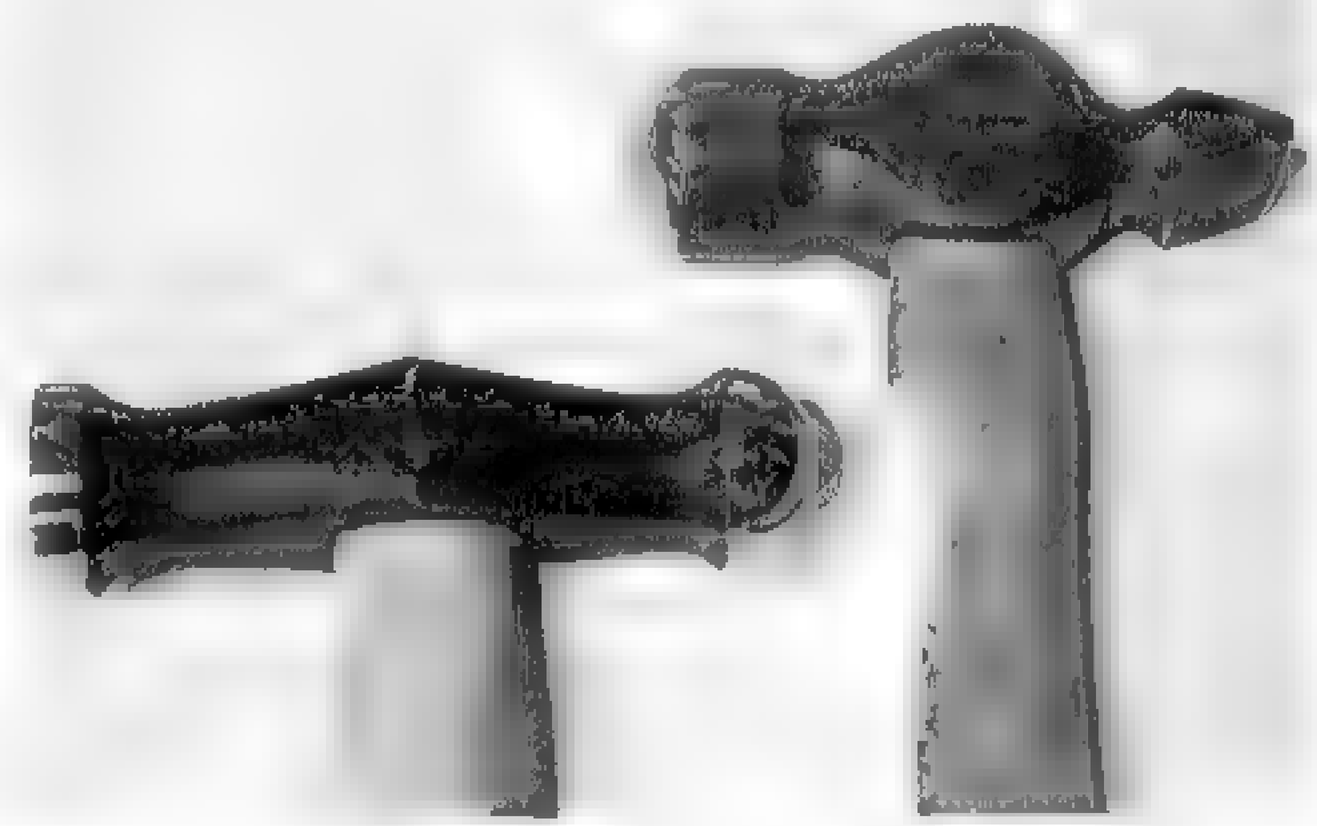


Figure 6.13. Hammers with domed faces are used to stretch metal and to smooth or flare it from the inside. Because the faces are round, they stretch the metal in all directions

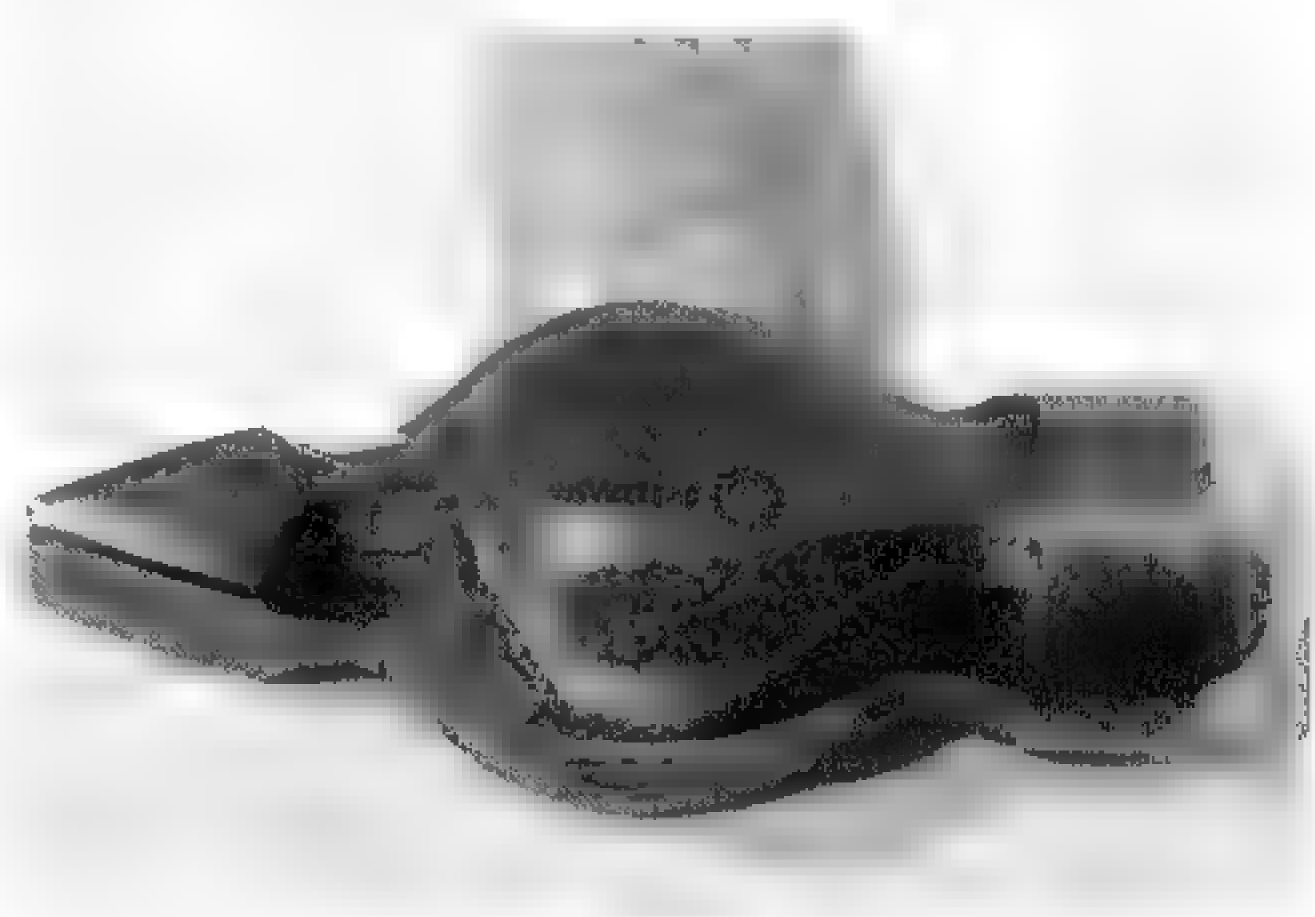


Figure 6.14. This hammer was ground from a standard Peddinghouse ball-pien. It was one of the first hammers I modified and has proven useful for many years

sphere. The use of this face gives the hammersmith good control over where the metal is being pushed. On a doming hammer, the force on the metal is outward in all directions, as opposed to the directed nature of force in a raising hammer. Raising hammers are as likely to be used on the inside as on the outside since the marks made are generally shallower and more controlled. Most advanced rough work is done with raising hammers rather than with doming hammers because of their precision.

Smoothing Hammers

When the rough work is done, the metal must be smoothed to prepare it for polishing and to add the final hammer-hardening if such is desired. Smoothing hammers must have a very high polish because they transmit the striking-surface finish directly to the work. A chip or mar on the face of the hammer is thus repeated in the artwork over and over again, making the finish very difficult. For this reason most smoothing (or "planishing") hammers feature round faces to avoid the chance of a corner ruining the work in the final stages.

Where to Look for Hammers

There are several places you should start: the local swap meet, an auction house (both physical or on-line auctions are good sources), a used or antique tool supplier, or a smith supply house. Also, there are a number of small businesses dealing in used tools that cater to the reenactor market. Wherever you look, you will probably find ball-pien hammers in huge numbers, followed by auto body hammers. All tend to vary wildly in terms of quality, so use care and don't pay too much for junk. That said, an excellent hammer is worth the price.

If you are just starting out, go first to a swap meet. There you will find hundreds of ball-pien hammers and, if you are lucky, a few others as well. You might well find a weighted rawhide hammer or auto body hammers, which can easily be modified (although they tend to be a bit light). Don't worry about whether they are mounted or not: you can often find boxes of hammerheads that you can get at a very low price.

Another excellent place to start is through on-line auction houses. Searches for

Figure 6.15. Shallow doming hammers are used primarily for bouging or planishing on the inside of a piece. They are almost never used on the outside because of the round marks they leave on the metal's surface.

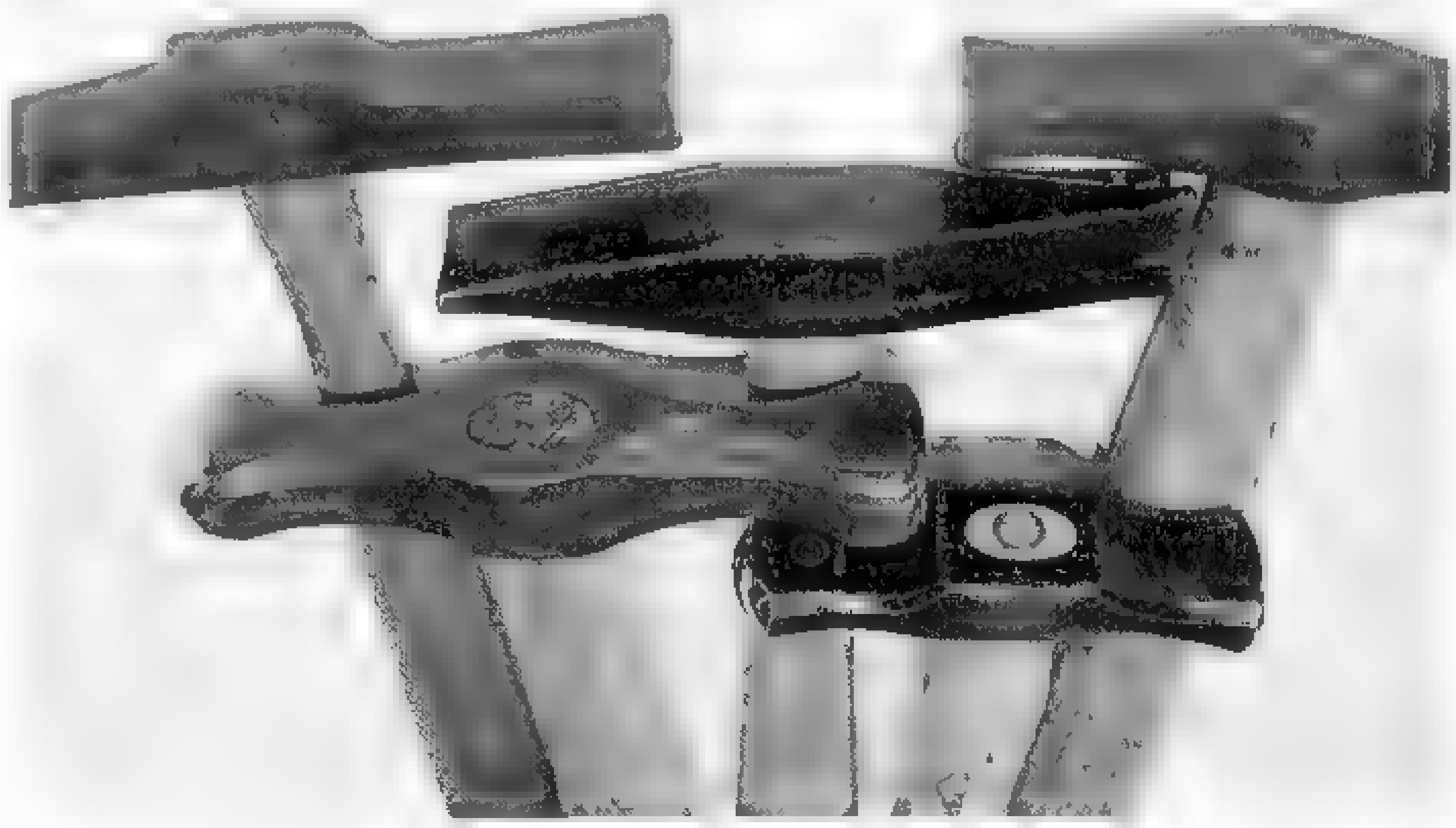


Figure 6.16. A variety of raising hammers are useful to the armourer. They are very difficult to find outside of specialty catalogs. Most surplus hammers are for silver- or coppersmithing, which require far less mass than the armourer requires. These hammers range in weight from .66 to 2 pounds.

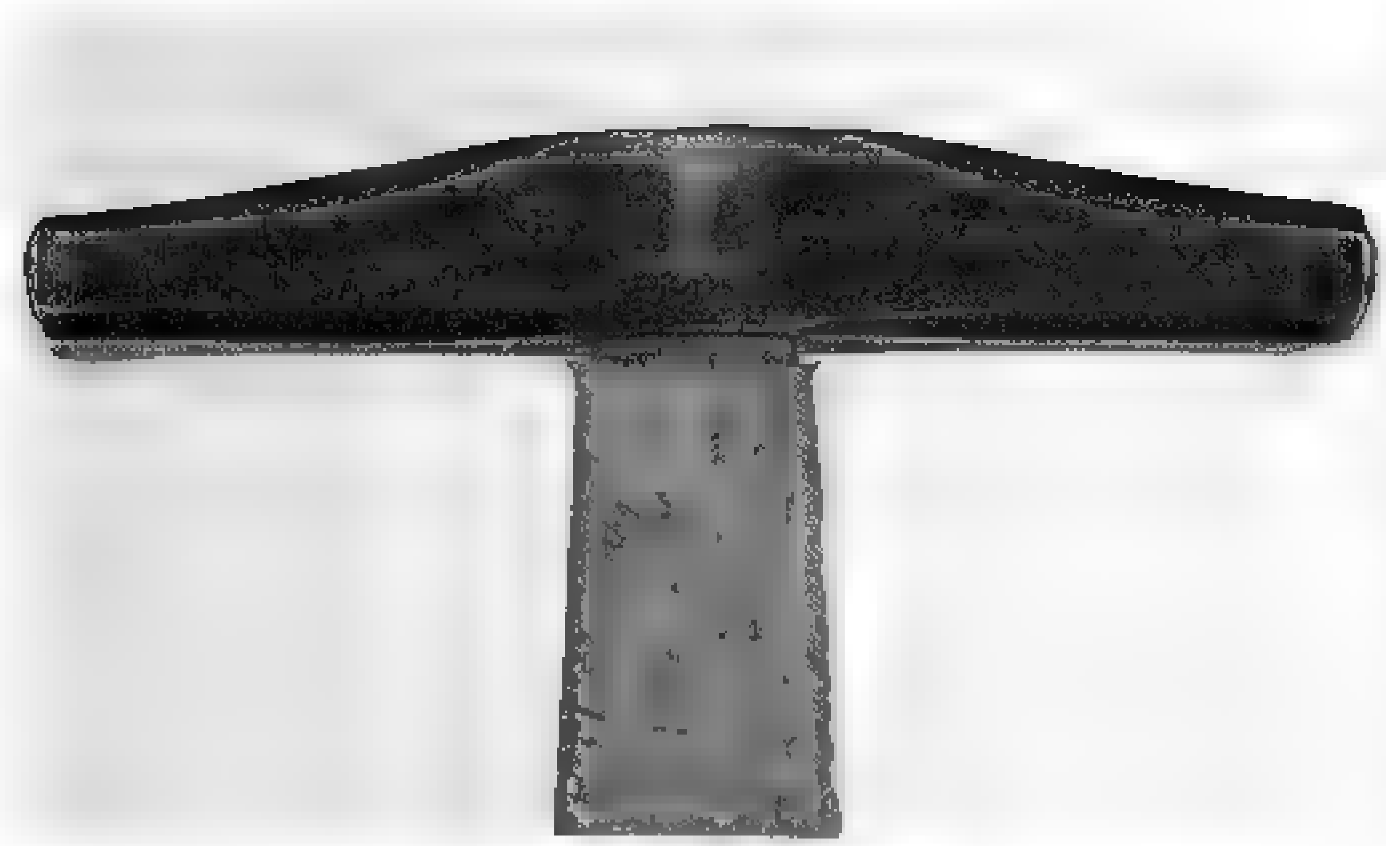


Figure 6 17. Raising hammers are used by intermediate and advanced armourers to "shrink" metal around forms, working from the outside with far greater control than is possible with doming techniques. A variety of raising hammers are essential to the armourer's advance past the most elementary projects

Figure 6.18. A variation on the raising hammer a flat-faced rectangular hammer is used for detail work such as fluting, edge rolling, and sometimes planishing around creases This hammer purchased from Anchor Tool, is formed from very high quality drop-forged steel

Figure 6 19. Smoothing hammers come in both round and square faces They are used for detail work and for planishing the metal from the outside. General purpose hammers are generally round, while detail hammers are often square

Figure 6.20. This commercial planishing hammer by Peddinghouse is very heavy and serves well for most smoothing jobs.

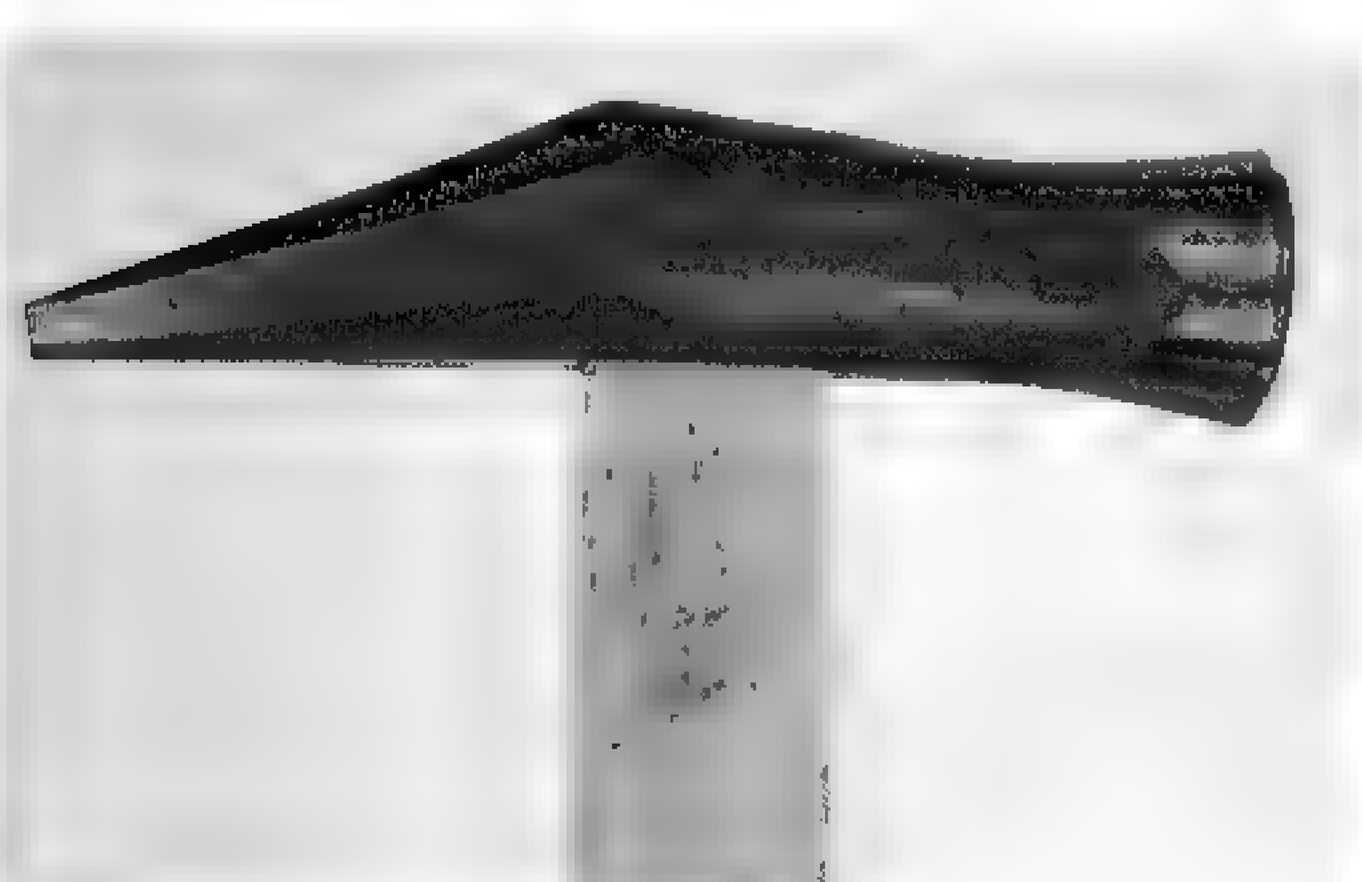


Figure 6.21 Japanese copper or boat-working hammers can sometimes be had through specialty catalogs. The shape is nicely optimized for planishing on light- or medium-weight material.

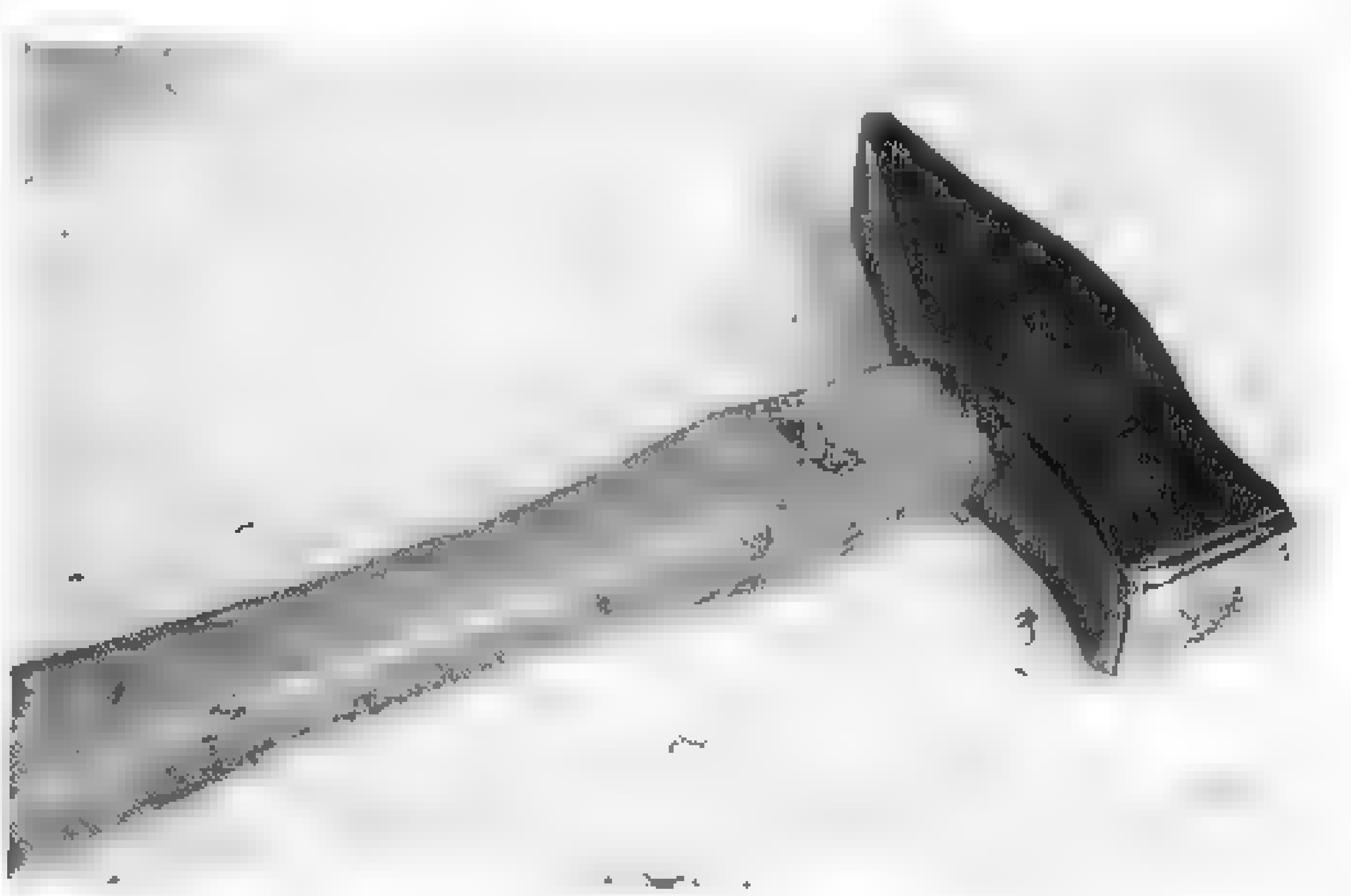


Figure 6.22 This square faced cross-pien was purchased at a swap meet and turned out to be immediately useful The square face snugs up nicely to creases and other hard-to-reach places

"blacksmith" on auctions such as eBay will result in many returns; the novice armourer can quickly locate anvils, leg vices, and a variety of hammers this way. The only difficulty is that the items cannot be examined closely in advance, and the bid prices are sometimes excessive. But in the last year, on-line auctions have come into their own as a new electronic marketplace and promise to ease the problem of finding appropriate tools of all kinds.

At an auction house, look for "lots" of tools that have several hammers in a single group. Usually there will be other tools in the lot, which sometimes will prove useful.

With used tool supply or antique tool shops, you stand a good chance of finding hammers that are of better quality, but the price is likely to be on the high end, sometimes approaching unbelievable.

In the United States and Great Britain, there are several suppliers where basic hammers can be acquired. These hammers will likely not be exactly what you need, but it is a good start and some of them are of excellent quality.

Lastly, the reenactment community itself has generated enough demand to support several small businesses supplying secondhand armouring and smithing tools. The quality is uneven, but you will find items unavailable anywhere else.

Hammer Quality

With a little searching, you will find *hundreds* of hammers. How do you determine which ones are good and which ones are better left behind?

The first thing to remember is that older is very likely better. Modern mass-production techniques, including simple sand casting, have largely supplanted the older, better quality, but more expensive drop-forge techniques. The denser the hammer, the more "life" it has—it will spring back after each stroke and will impart more force to the work. Hammers of a lesser quality will be more porous and will not hit with the same kind of authority. Additionally, the finish on the face of finishing hammers will not be as crisp.

Secondly, hammers don't "age." Often the nastiest, rust-encrusted hundred-year old hammer will prove to be vastly superior to the shiny new one. Of the new hammers, Peddinghouse and Anchor are the best quality. I have also had good luck with some of the Japanese hammers, especially large-faced smoothing hammers.

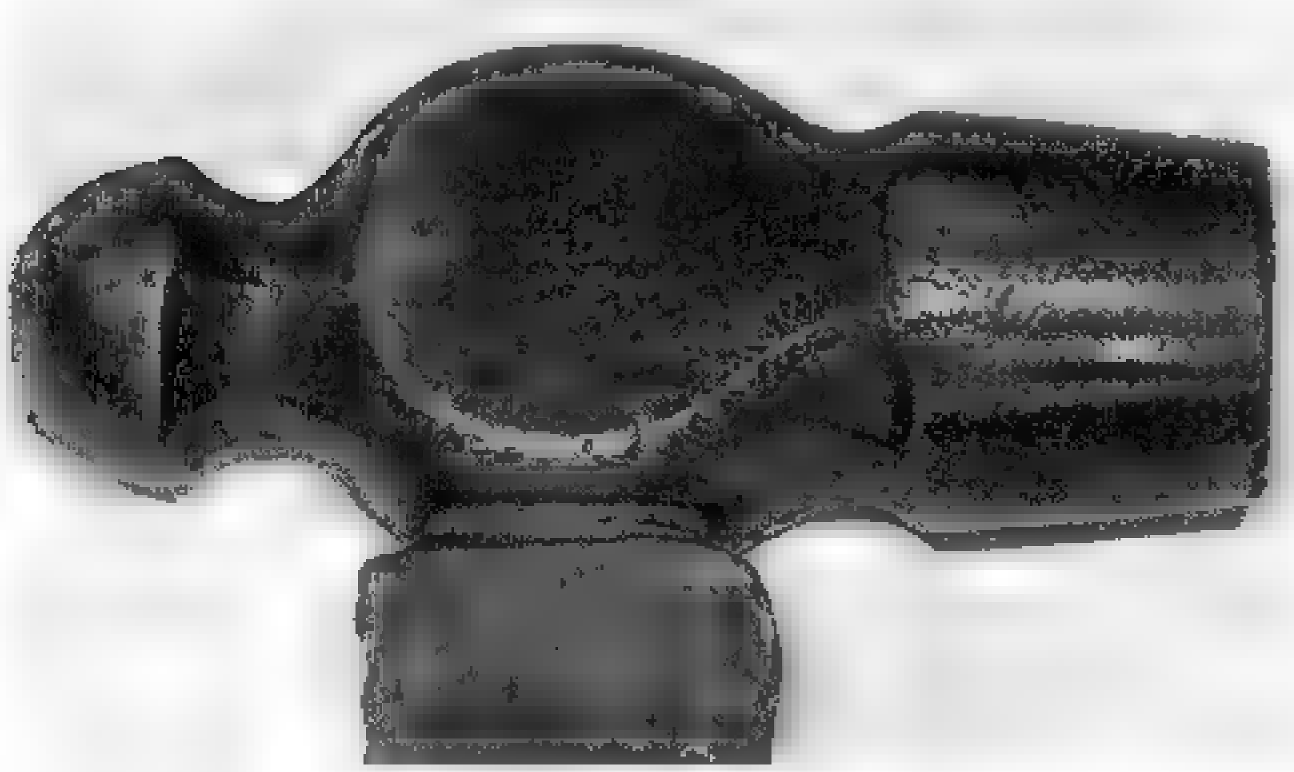


Figure 6 23. At swap meets and auctions you may find boxes of ball-pien hammers, which are useful for setting rivets. If the steel is of good quality, they can be modified as needed for specialty work

Modifying a Hammer

While it is difficult in the extreme to obtain a full complement of hammers at the outset, an aspiring armourer can make do with a range of commonly found ball-pien hammers, modifying these to meet his needs and adding other hammers as they are found.

Commercial hammers can be modified by grinding. Care should be taken that the grinding be done slowly so that any temper is not removed; the metal should not become discolored with heat and should be quenched frequently to keep it cool.

Hammer Faces

An armourer's hammers should always be kept highly polished because the hammer's face comes into direct contact with the metal's surface. Perfectly polished faces, especially on planishing hammers, are a sign of a professional armourer and skilled craftsman.

The same polishing techniques used to bring the armour to a high polish are used on the hammer face. A rougher grit is first applied to a new hammer, followed up with a white

stainless compound. The white compound is used to maintain the finish, the hammer face polished quickly before every use.

Replacing a Hammer Handle

There will be many times when you will have to rehandle a hammer (figs. 6.27–6.30). Inexpensive handle blanks are available at swap meets and most hardware stores. They often come complete with a ribbed wedge that expands the wood at the end passing through the hammerhead, securing it in place.

A Note on Power Hammers

There is a tendency for novice and intermediate armourers to spend a great deal of time, effort, and sometimes money searching for a power hammer that will take the place of the even, accurate hammer stroke necessary to produce fine work. However, it is a safe bet that if you haven't been able to refine your eye and discipline yourself to develop the required skill with a hand-held hammer, then a fancy tool isn't going to give you the effect you are looking for. Spend the time (and save the money) and develop your skill with the hammer while simultaneously refining your eye. If you can accomplish this, then you are well on the way to grasping the armourer's art.

STAKES

Next to hammers, stakes are the most valuable equipment in the workshop. Stakes are dense steel forms over which the metal is compressed and shaped or into which it is pressed. Unfortunately, they are also difficult to find.

Generally speaking, forms used for silver- or coppersmithing are too small and not dense enough to support extensive working at the pressures required for the working of sheet irons and steels. For the purposes of armouring, the beginning craftsman must make do with available forms, but if you desire to continue with the art, then you must become adept at finding stakes and at modifying forms to become specialty stakes.

Like hammers, you will find a multitude of stakes in an armourer's workshop, but most of

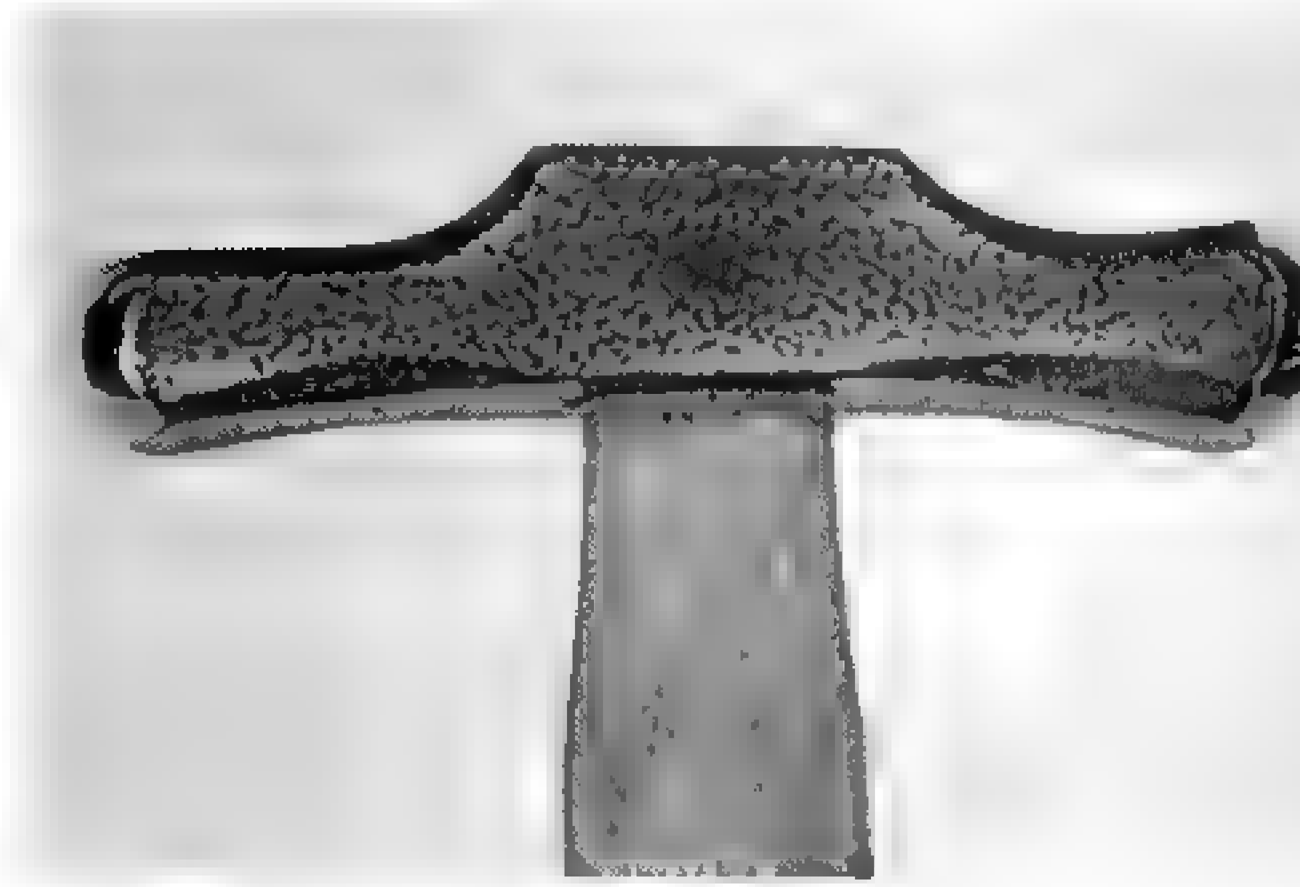


Figure 6.24 This hammer was purchased from a commercial source and modified into the hammer shown in Figure 6.25

Figure 6.25. This hammer is my favorite, a modified Peddinghouse with the bulbous face flattened, retaining the soft edges. I use this hammer as my default for nearly everything from raising to creasing to flaring to fluting

Figure 6.26. A hammer's face should always be kept highly polished, both as a sign of professionalism and because any flaw in the hammer face is transferred to the armour's surface each time the hammer strikes

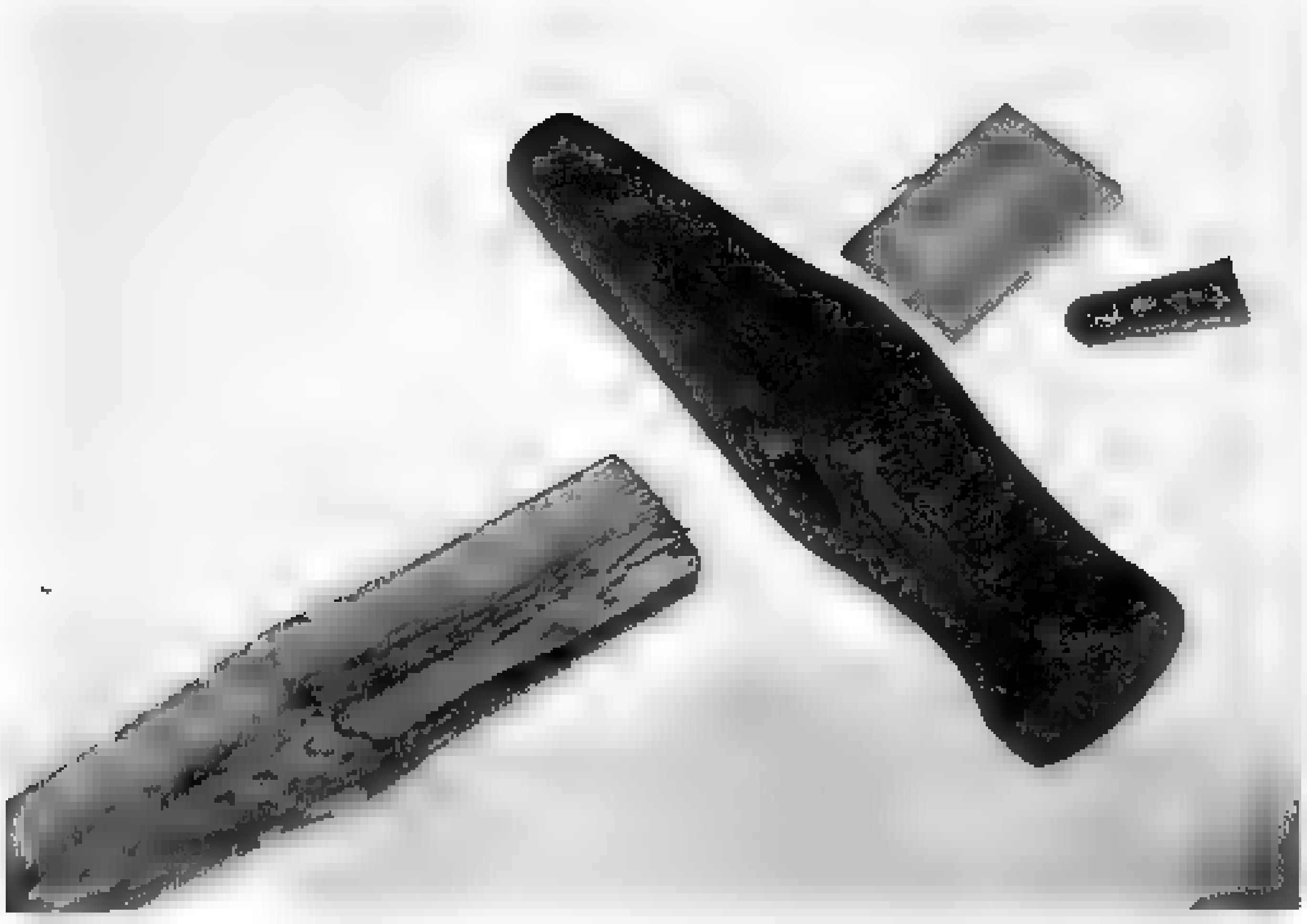


Figure 6.27. The items necessary to rehandle a hammer: handle, hammerhead, sand paper, and wedge

Figure 6.28. First mark the point to which you must sand, then carefully sand to this point, checking the fit frequently.

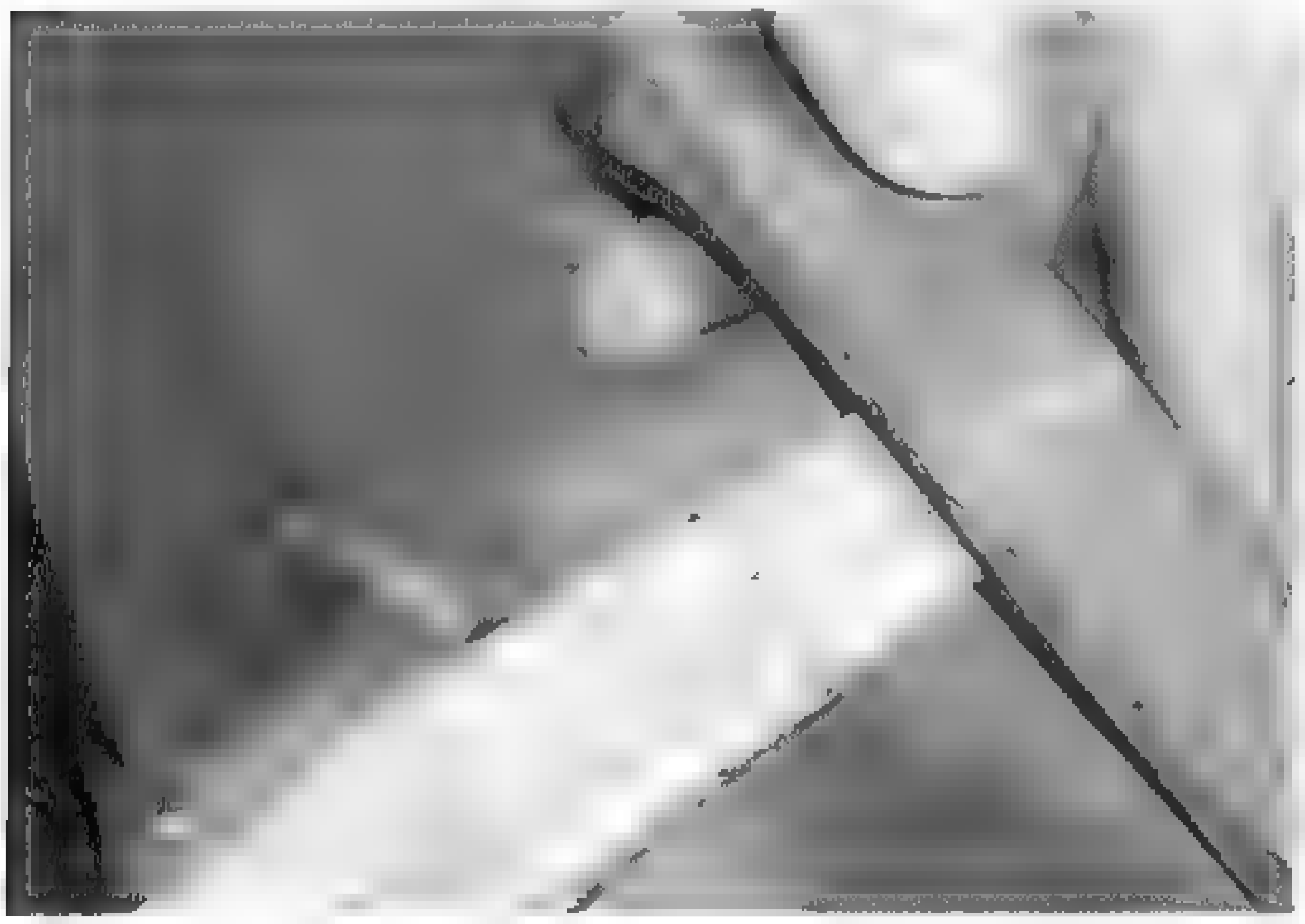


Figure 6.29 The hammerhead must sit perpendicular to the handle for optimal balance

Figure 6.30. The wedge is then hammered into the wood through the head with another hammer, securing the hammerhead in place

Figure 6.31. The six hammers at left will get the novice more than started and are easily available from commercial sources From left to right: modified cross-pien unweighted rawhide; modified ball-pien from Peddinghouse; weighted rawhide, double-faced planishing hammer standard ball-pien

the work is done over a few simple stakes—an anvil or railroad rail, a ball stake or two, a dishing form of some sort, and a creasing stake. The benefit of having a large selection is the precision gained by working over a stake that is close to the final desired shape.

Anvils

An anvil is not an absolute requirement for the novice armourer, but it is highly recommended and will save hours of work versus trying to do the same thing over a stump. It is where the heaviest forming can be done. Light doming, smoothing, creasing, and bending can all be done over a good anvil. Ideally you want a very smooth surface without any marks, sharp and clean edges that can be used for edging and creasing, and a good horn (for armour, longer horns are generally better, though medieval anvils were often double-horned and featured short horns).

An anvil must be large and anchored, bolted to a stump, stand, or other secure place. The anvil in armouring is not as critical as it is in other smithing operations, but it will be useful on almost every project.

You can purchase good quality anvils brand new. The advantage of buying a new one is that the quality and composition of the steel is known, the face is dead flat and polished, and the edges crisp and sharp. The best ones come from England, Sweden, or Germany, but they are expensive to both purchase and ship. Others are made in China or South America, but I have found these to be of a lesser quality in terms of steel density, something you can test by the "ring." You can find them at smith supply houses or, sometimes, at horseshoe maker supply houses.

The anvil's face should be as polished as you can get it. Care should be used to keep the face unmarred and free from rust, because these imperfections will transmit themselves perfectly into the work and will be difficult to remove. Never strike the anvil face with a hammer—it will leave a deep mark. The edges should be sharp, because they will be used to define the edges of flares and other details. New anvils have the advantage of being perfect in these crucial areas, but you will pay for the precision.

New anvils range from two to four times the cost of used ones. Used anvils, by contrast,

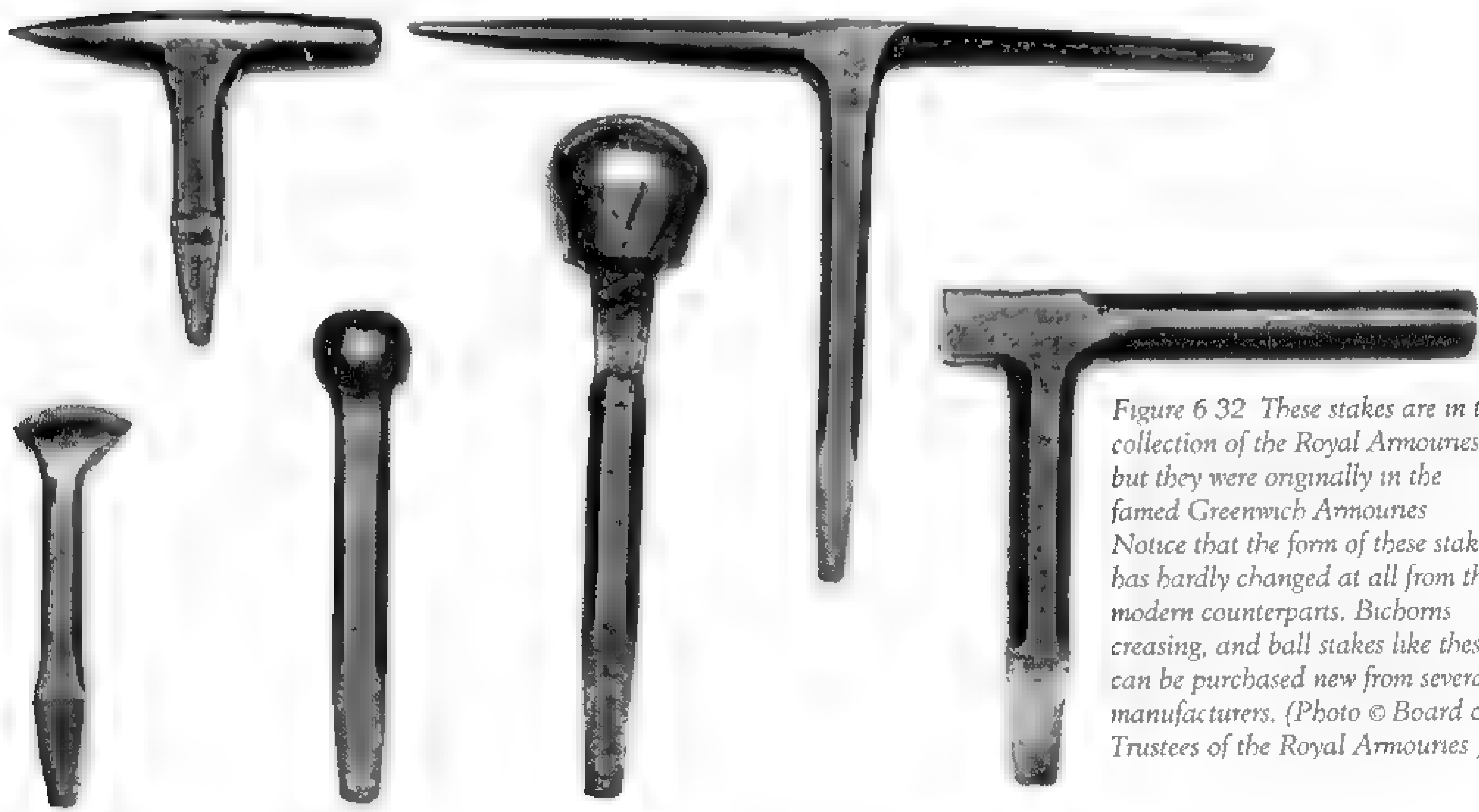


Figure 6.32 These stakes are in the collection of the Royal Armouries but they were originally in the famed Greenwich Armouries. Notice that the form of these stakes has hardly changed at all from their modern counterparts. Bichorns, creasing, and ball stakes like these can be purchased new from several manufacturers. (Photo © Board of Trustees of the Royal Armouries.)

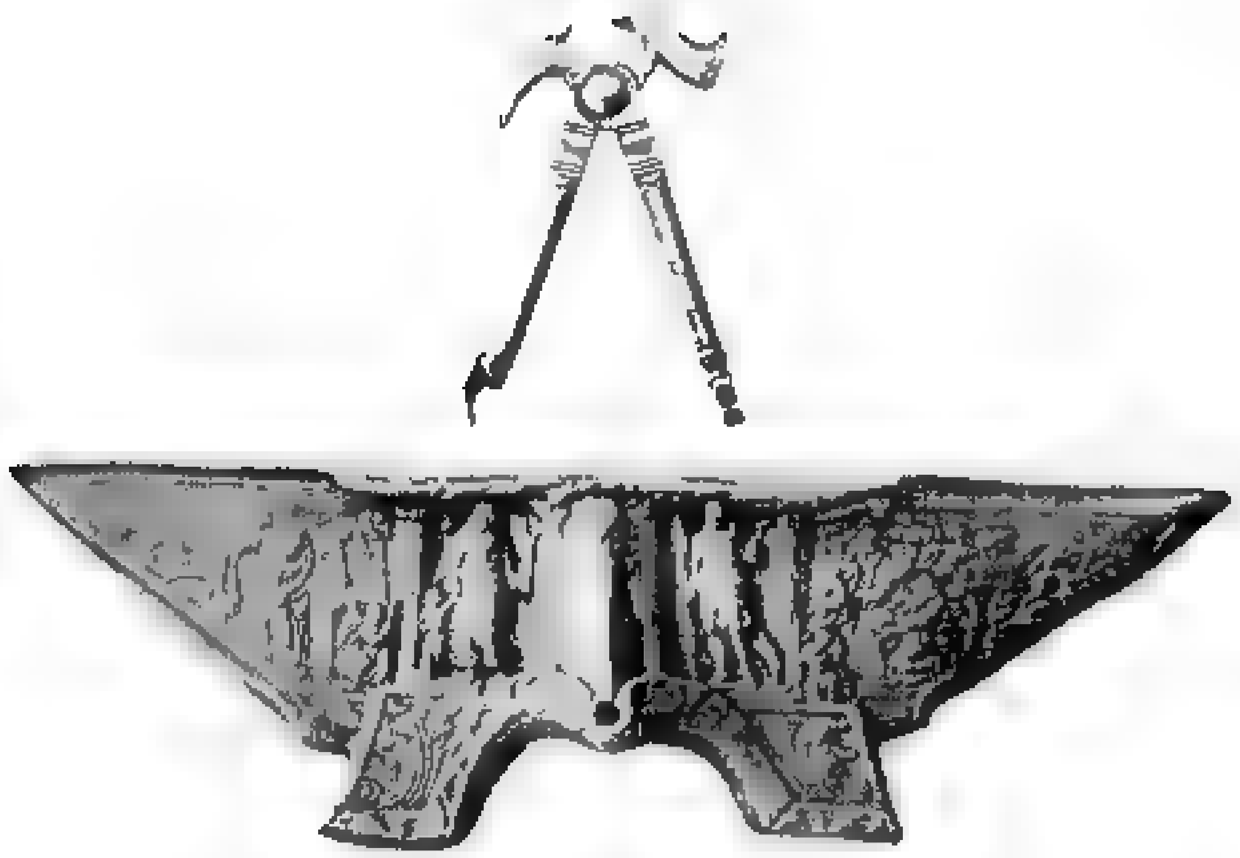


Figure 6.33 An anvil is one of the oldest armouring tools. This one, originally from the British Museum, is an armourer's anvil from the 16th century. The tool above is a pair of snips from approximately the same period. (Photo courtesy of the Trustees of the British Museum.)

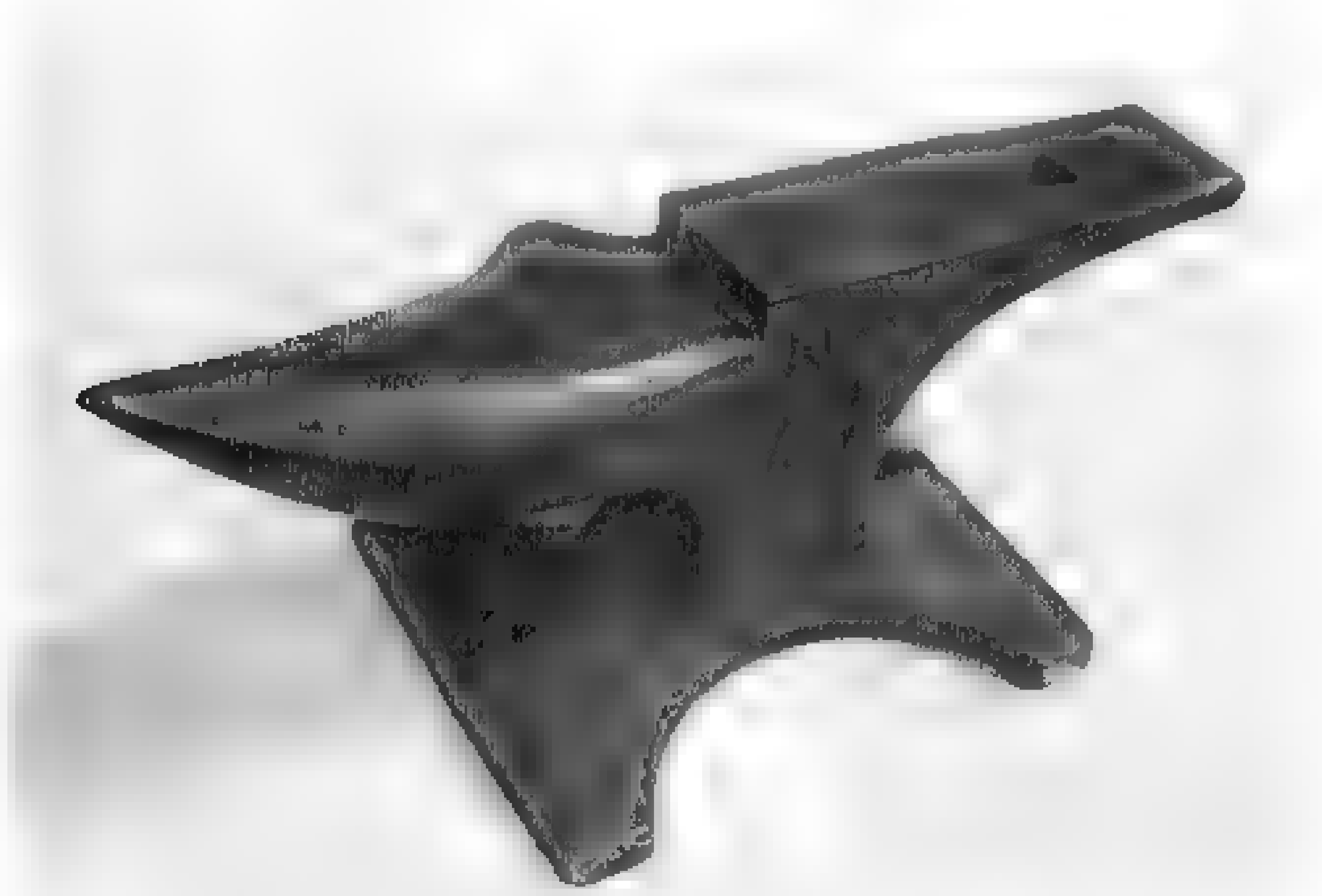


Figure 6.34. Used anvils can often be purchased fairly reasonably over the Internet or at farm auctions. Look for good, sharp edges and a clean face. As long as the horn is intact it will serve even if scored

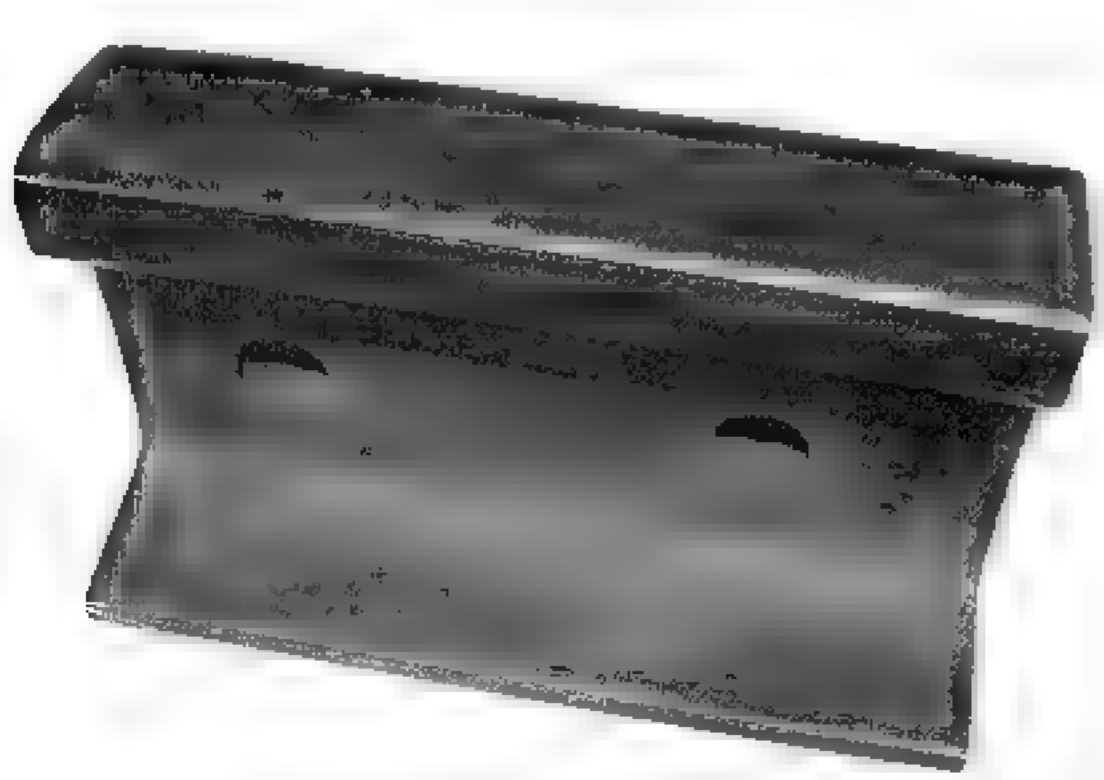


Figure 6.35 Railroad rails make excellent anvils A sharply cut edge is exceptionally useful for creasing and flaring operations, since the steel quality is usually outstanding.

can often be found for an extremely reasonable price. The price fluctuates depending upon the quality of these crucial elements, but the cost savings can often make them worthwhile. In some instances they can be resurfaced with hard metal if they do have pits and imperfections. Ask at your local welding shop for more details.

Look for used anvils at auctions and used tool dealers. Because they were standard farm equipment into the last century, used anvils of good quality are available everywhere except for some reason the West Coast of the United States. Farm auctions are another good place to check. Lastly, the same dealers who sell hammers might also be able to supply you with a good quality used anvil, but remember to add in the shipping costs.

As with other tools common to the blacksmithing trade, anvils can often be located through on-line auctions, but you must exercise caution with respect to the price and quality of the purchase. And remember that anvils are very heavy and expensive to ship.

Unless you intend to pursue armouring as a vocation or have a good deal of money to burn, spend the time to find a used anvil.

Railroad Rails

Sections of railroad rail (the metal rails that the train wheels run on) are extremely useful whether or not you manage to find a good anvil. They are of excellent quality, are already hardened, and can be gently sanded into a variety of shapes. Although you must cut them with an oxyacetylene torch or plasma cutter, they can sometimes be found in railroad yards, where a few polite words might net you more "scraps" than you can carry. If not, local metal scrapyards might have some or know where they can be found. They are inexpensive (you probably won't pay more than the going rate for scrap, at the time of publication roughly $.25/lb.) and extraordinarily useful.

Rails clean up rapidly and can be modified into many useful tools. If you are fortunate enough to find a section roughly a foot long, you can sharpen one end using the natural arc of the rail to give you a perfect edge for flaring

or creasing. This edge is extremely useful for rolling the edge of the metal.

If you can't find an anvil or can't afford one, use a section of railroad rail. It won't be exactly the same because the face isn't flat, but you can do most things with it.

Horns

Much armour is of "gutteral" form, or tubular in shape. To bend metal into these shapes, various "bichorns" (fig. 6.36) are used in conjunction with a rawhide hammer (where simple bends are required) or metal hammer (for the better pieces, where the steel-on-steel pressure fixes the curve in place).

To handle the force necessary to move large sheets of metal (as with the cuisses, or thigh defenses), bichorns need to be large. You can clamp them into a large bench vice, sink them into a stump, or place them properly into a stake plate. The value of a long horn (they tend to run 30 inches) is that you have a more or less cylindrical surface that can be used to make tubular shapes. Shorter horns, such as those found on anvils, tend to be tapered more dramatically. It is more difficult to make a parallel curve over these horns, so the bichorn is preferable.

New horns can be found from the same sources that deal in hammers, stakes, and stake plates, but they are expensive. Used ones might be found from used or reenactor tool dealers

If you can't find or afford a horn right away, similar work can be done over the anvil horn or over part of the railroad rail. It will just be a little more difficult.

Dishing or Doming Stakes

No piece of a fine armour is flat; each plate on a quality harness has some measure of flair, dish, or shape to it. The hammerwork required insures better control over the fit and relationship to the plates around it, making for a better engineered harness and one that has more artistic merit.

Medieval armourers probably did very little doming, preferring to raise their work from the outside. Some rudimentary doming may have been done, but no stumps, sandbags, or dishes are illustrated in period manuscripts. What doming was done was likely performed on a flat anvil surface.

Modern novice and intermediate armourers tend to dome a great deal, constructing their pieces from welded sections because it is easier and faster than raising. Working into a wooden stump, steel dish, or leather sandbag, a simple "domed" shape can be executed quickly from a flat sheet, yielding instant results. As the armourer's skill increases, more and more work is done from the outside, but the dish will always be a place to start to roughly define where curves will go.

Many novice armourers work into a wooden stump to dome their pieces. After

Figure 6.36 Though expensive, bichorns are exceptionally useful for creating gutteral shapes and rolling edges

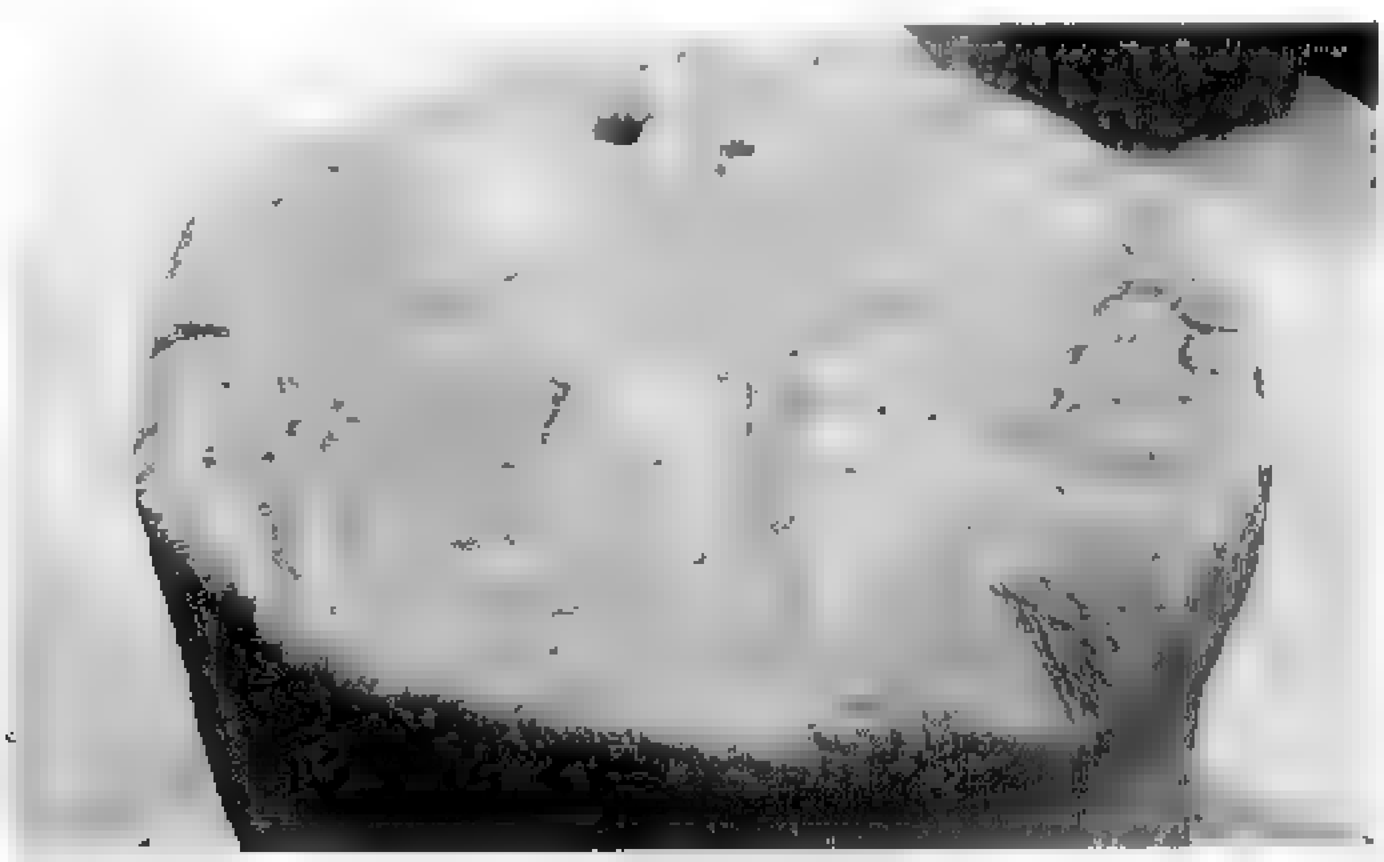


Figure 6.37. The easiest tool for the novice armourer to make is a simple dishing stump. A leather band 1 inch wide can be nailed around the stump to serve as a makeshift hammer rack

Figure 6.38. A cut-off cylinder makes for an excellent doming stake

Figure 6.39. Steel punchings make excellent doming stakes when they can be found

finding a good quality stump, a sander can be used to hollow out a section approximately 4 or 5 inches in diameter and about an inch deep.

Another tool I have found effective for doming and rough forming is a leather sandbag. You can purchase one or easily make your own by filling a heavy leather bag with simple sand or #9 buckshot.

Beyond the sandbag, discarded welding tanks can be used as doming forms (fig. 6.38). When tanks are found to no longer be safe, welding supply houses are required by law to render them useless by sawing them into at least two sections. The bottom of such failed cylinders sometimes features a dome ideal for a new life as a steel dishing stake. In order to determine if the bottom of a cylinder has a useful curvature, look for shapes that are nearly spherical (those that are shallower are, in general, more useful than the deeper ones).

Never cut a cylinder on your own! There is a high risk of explosion from cutting a cylinder, so they should only be purchased already cut from a welding supplier or scrapyard. The gas must first be completely purged, and this is impossible to do at home in such a way as to guarantee absolute safety during the cutting phase.

Once you have the cylinder, I strongly recommend filling it with sand and welding it closed along the bottom seam. This done, you will vastly reduce the noise made when pounding metal into the form.

Lastly, in some cities with heavy steel-working capability, scrapyards sometimes obtain large punchouts not dissimilar from a "slug" or Whitney punch slug (fig. 6.39). These slugs are larger, sometimes as much as 3/4 inch thick. A shaft cut from a commercial bolt can be welded onto the bottom, and they can be affixed to a forming bench. These dishes are very hard to find, but they are extraordinarily useful.

For the construction of cuirasses (the full steel carapaces that defends the trunk of the body), extremely shallow and subtle curves are required. One armourer that I know had a commercial metal shop turn a very shallow dish for him from 2 inch thick steel. The result was excellent, though expensive for someone not intending to produce armour consistently.

Ball and Mushroom Stakes

Ball stakes are the most basic armourer's tools. They are integral to forming, smoothing, and planishing steps, and you will find them useful in nearly every project. Ball stakes are either round or flattened on top, in which case they are referred to as "mushroom" stakes. It's likely that most medieval versions were mushrooms rather than spheres, but for modern armourers the spherical versions are much easier to obtain.

Round or mushroom stakes are frequently pictured in medieval manuscripts. It is likely that much of the medieval armourer's work was done hot over a simple stake rather than over those made for a particular purpose.

Because of their heavy use, it is important to obtain the densest stakes possible. These can sometimes be found from commercial smith supply houses or jewelry vendors, but use care; ball stakes appropriate for silver- or coppersmithing are often too porous for work on steel. Either you will find the round top collapsing from the force, or the stake will shatter at the base.

Ball stakes generally come in two styles: straight and offset. A straight stake (fig. 6.41) is simply a steel ball welded to a post that acts as a shaft and can either be clamped in a vice or set into a stake plate. The problem with such stakes is that you cannot always maneuver a piece to set precisely on the ball. Fortunately, offset ball

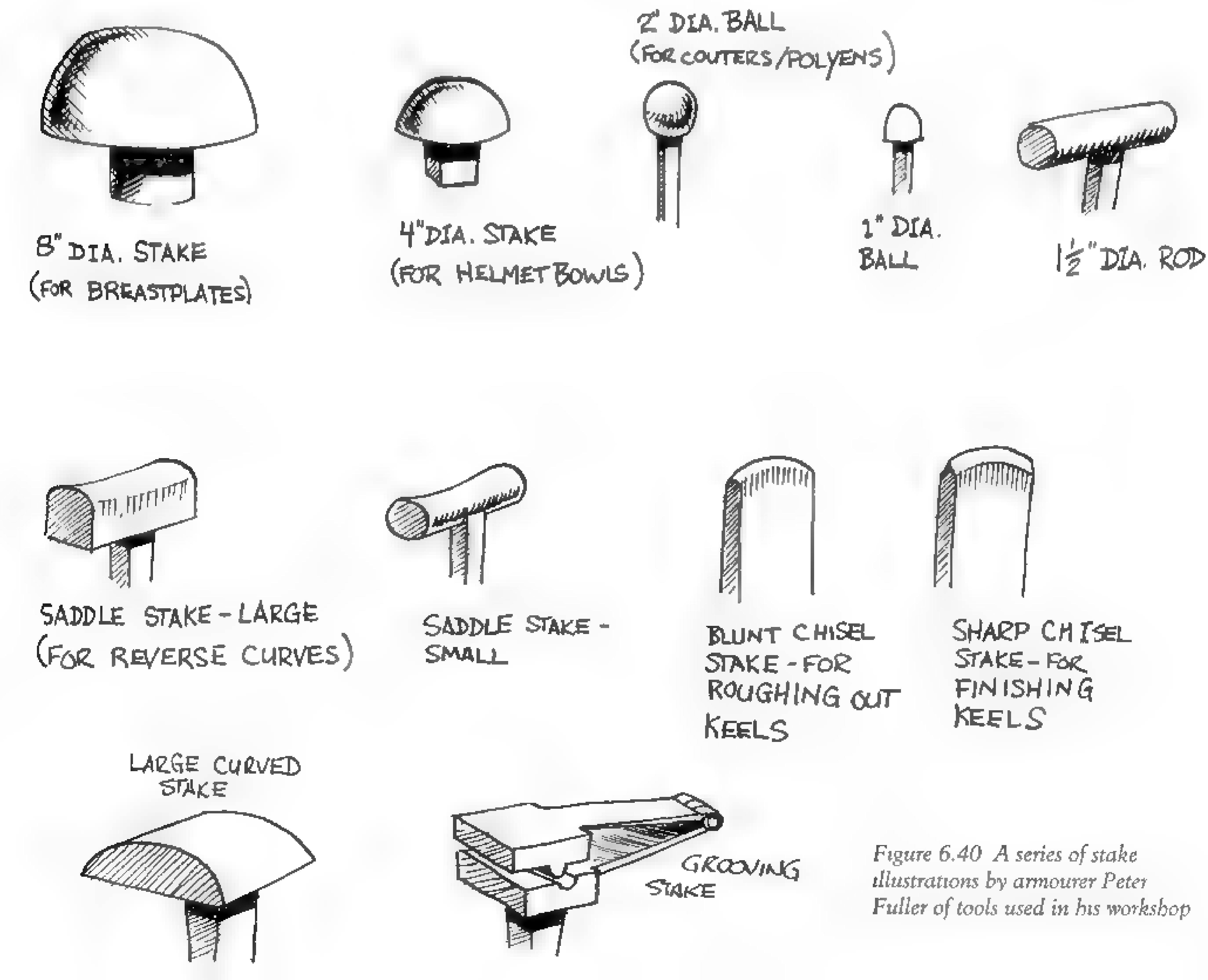


Figure 6.40 A series of stake illustrations by armourer Peter Fuller of tools used in his workshop

stakes (fig. 6.42) provide a solution. The shaft is mounted such that only a short amount of the stake protrudes from the ball, the rest forming a step extending down into the vice or stake plate. Using this configuration, more of the ball is accessible for forming operations, but it does not channel force from the hammer blows as effectively. Ideally an armoury would be equipped with ball stakes of all diameters in both straight and offset patterns.

Fortunately, reenactment vendors frequently provide a large selection of ball stakes made from concrete-smashing, high-carbon steel balls ranging in size from 1 to 5 1/2 inches. Alternatively, you can acquire the balls from similar sources and weld your own (they are immensely useful for making stakes of all descriptions because of their high carbon content), or you can purchase a stake or two from the commercial houses. Ball stakes are almost never found in the used tool or antique markets.

Figure 6.41. Ball or mushroom stakes can sometimes be made from concrete-crushing balls welded to a simple steel shaft. Others, like the one here, were made commercially in the late 19th and early 20th centuries but are now very difficult to find

Figure 6.42. An offset ball stake is exceptionally useful. Given a choice between a straight and an offset stake, the armourer should select the offset because it offers greater freedom in maneuvering the piece over the working surface without interference from the shaft. Straight stakes are better for heavy raising and forming because they diffuse less of the hammer's force

T-Stakes

When your work advances beyond the beginning level, a T-stake becomes immensely useful for flaring and riveting operations. So-called for their shape, which resembles the letter T, either end can be used for different kinds of flaring and raising operations. Most of the rough work on fine armour ideally should be done on such a stake, so they are valuable if they can be found. In addition, they are extremely useful for final assembly because they present a flat surface for holding a rivet in ways impossible on an anvil or within a lead block.

Some of the right shapes are available from jewelry tool vendors, but you must select the largest models. To stand up to the heavy abuse found in the shop, they should be 14 inches or so front to back and should weigh at least 15 pounds. Often, however, you have to settle for a very limited selection or make your own.

Making your own T-stakes is attractive only because they are so hard to find, new or used. They have few applications outside of art metalwork, and most of the art stakes are far too light for use on steel.

To make a stake, take a piece of good wood such as oak and grind the shape you want, then take this wooden master to a short-run steel foundry and request one or more of them poured in a high-carbon steel. Although expensive, the result can be rewarding and very useful.

The swooping curves of a good stake make flaring operations possible. For pieces that are as difficult as a greave (the lower leg defense), a custom-made stake saves not hours but days of intensive work.

Creasing Stakes

Most good pieces have either a central ridge or flutes

decorating the surface. To place a central crease on a flat surface, a good sharp edge on an anvil, railroad rail, or bichorn can be used. However, to place such a crease on a domed surface, an edge is required that holds the arc of the surface yet provides a sharp enough surface to define the ridge. A high-quality edge in the form of a stake of very high carbon steel is required for this since many thousands of hammer strokes will impact the edge itself.

In order to get to most of the places required, the stake should also be offset (fig. 6.45). While a single creasing stake will be sufficient for the aspiring novice, many will be required as time goes on. They can be made or purchased, although they are very hard to find used. The best sources will be silversmithing supply houses or reenactor tool vendors.

Figure 6.43. A general-purpose T-stake like this one is exceptionally useful for raising, flaring, and even setting rivets.

Specialty Stakes

Throughout your efforts to create more and more complicated examples of the armourer's art, you will require an ever-expanding supply of custom stakes tailored to the shapes you want to create. Keep on hand a supply of high-carbon steel, old files, bits of railroad rail, and seemingly useless steel tools of good quality to help you along, since these materials can always be ground into shapes to assist you.

If you are very fortunate, you will be able to find specialty stakes in a mystifying array of shapes and sizes originally used for shoemaking, smithing, or unknown ancient crafts. Keep these about and be ready to

Figure 6.44. An armourer works a breastplate, likely laying the flutes. He holds a raising or fluting hammer, working the piece from the outside rather than from the inside. From the Hausbuch of Mendelschen Zwölfbrüderstiftung, early 16th century

turn them into useful forms for your own work. Talk to other armourers and see what stakes work for them, and you will find new insights into tools that work for specific applications.

Stake Plates

To hold the stakes you create and purchase, you will need a stake plate. These cast plates feature a variety of holes useful for holding the gargantuan bichorns all the way down to the small ball stakes, so long as the stake shafts have appropriately tapered ends. Use care never to hammer a stake sideways in a stake plate or you may fatally crack the brittle steel tubes that hold the stakes firm

Medieval stakes were fitted with sharpened posts that allowed them to be sunk directly into the workbench or a stump, but modern stakes often have a tapered end that will slide into a commercially made stake plate. Once in a plate, a stake should find a firm seat and should not rock in any direction. The plate itself should be mounted solidly in a stand of some sort that will not travel, rock, or distract in any other way from the work at hand.

Stake plates may be found from various tool vendors, both new and used. Some hold only a single stake while others are roughly 30 inches long and can hold as many as six or seven stakes at a time. If you are fortunate to find plates at a reasonable price, mount them on different benches so that they can be moved around in a comfortable arrangement and several stakes can be made accessible at any one time. During every project, two or three stakes will be useful at any single moment, and you will find many times when switching stakes becomes time-consuming enough to prove irritating.

Figure 6.45. Creasing stakes are used extensively by the armourer for creases and fluting. One will serve at first, but eventually the armourer will want a collection in different shapes.

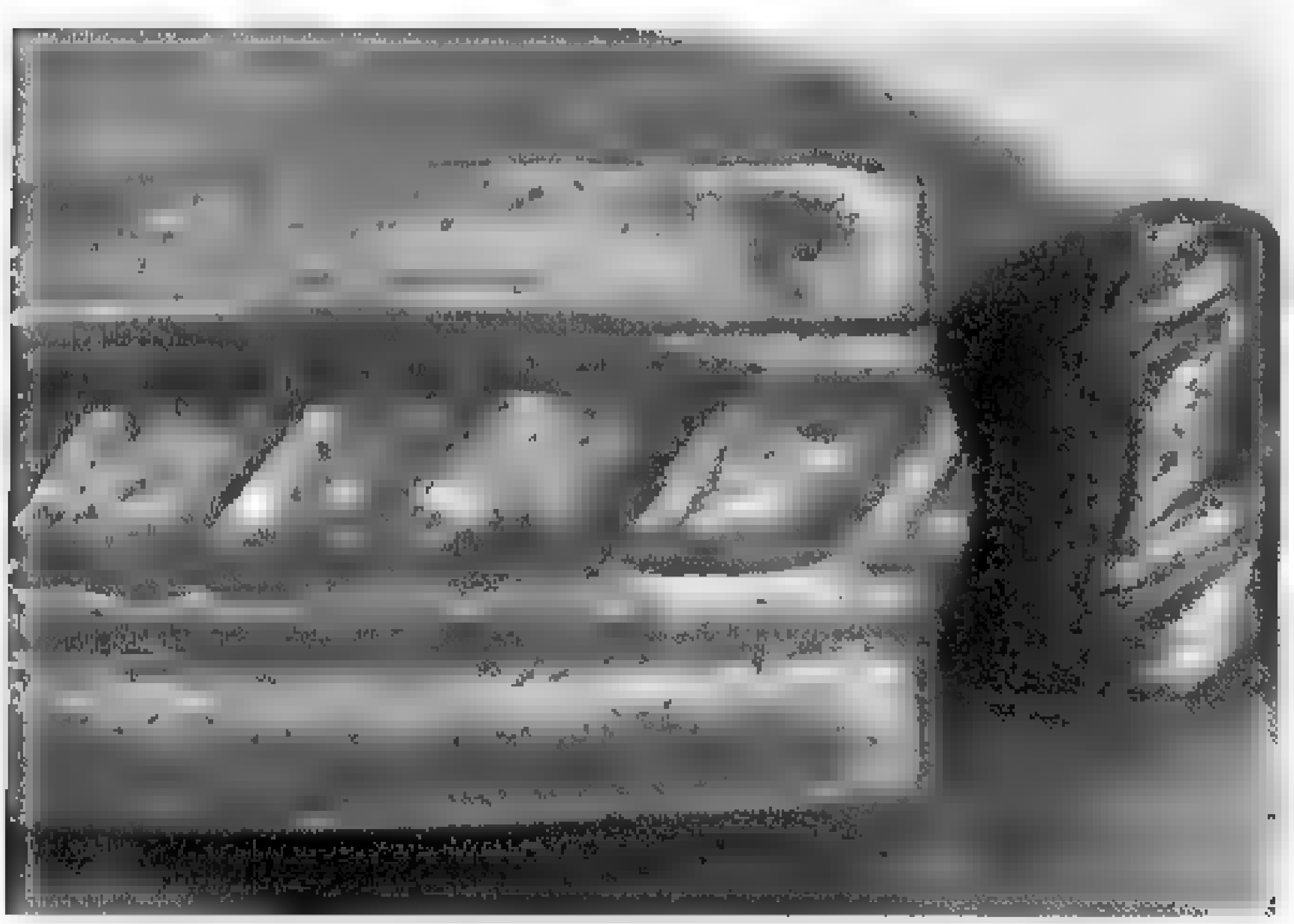


Figure 6.46 These roping stakes were custom-made by Charles Davis for use on 14th century gauntlet cuffs. The male was first sculpted out and the female heated to a red heat. The male was then driven into the female and cleaned up. The result is a fine tool for stamped roping

Figure 6.47. A stake plate, securely mounted, provides a stable forming platform

Bench or leg vices can also be used to hold stakes that don't feature the appropriate taper to fit into a stake plate. Many of the stakes available from the reenactment vendors will be this way, so you must clamp them into a vice to use them. If the vice is in the same work area as the stake plate, you will have a much easier time arranging appropriate stakes for the project in an efficient manner.

PUNCHING/DRILLING TOOLS

At some point during every project, holes must be punched into the steel for articulation, slides, or pins. Historically, there is evidence that holes were hot-punched into metal by means of some kind of punch and die, and medieval inventories speak of punches of varying types. Punches in the Middle Ages were probably not mechanical like their modern counterparts but were likely simply sharpened tools used to hot-punch holes in metal through holes set in anvils or other heavy bits of metal. Modern armourers have access to two excellent solutions for the same problem: the electric drill and the leveraged sheet metal punch.

Center Punches

To mark a hole before piercing, the position is carefully measured and marked with a permanent marker. Next the piece is marked with a center punch (fig. 6.48), the same sort commonly sold in hardware stores. Excellent quality punches can usually be found at flea markets, auctions, and the like for less than a dollar.

An interesting technical innovation is the automatic center punch, made in the United States by the General Tool Company of New York City. By way of a spring arrangement in the tool, this punch can be used with one hand without a hammer. This makes precision marking of holes to be punched much easier.

Punches and Dies

The medieval armourer likely pierced holes in armour using a simple sharpened punch and a hole with the desired diameter pierced through a firm surface such as an anvil horn. Using this technique, either hot or cold, holes can be quickly driven through sheet iron or steel in a very medieval—and easy to replicate—manner.

Electric Drills

Contrary to popular belief, electric drills need to be run slowly to cut metal most effectively. The torque of the motor is most important; a medium- or heavy-duty drill will be required. Drills can be obtained at flea markets or auctions, or they can be purchased new at any hardware store. Even if you obtain a Whitney punch, a drill will be used in many projects.

Drill Bits

Metal drill bits are required to cut through steel (tungsten bits are the finest). An

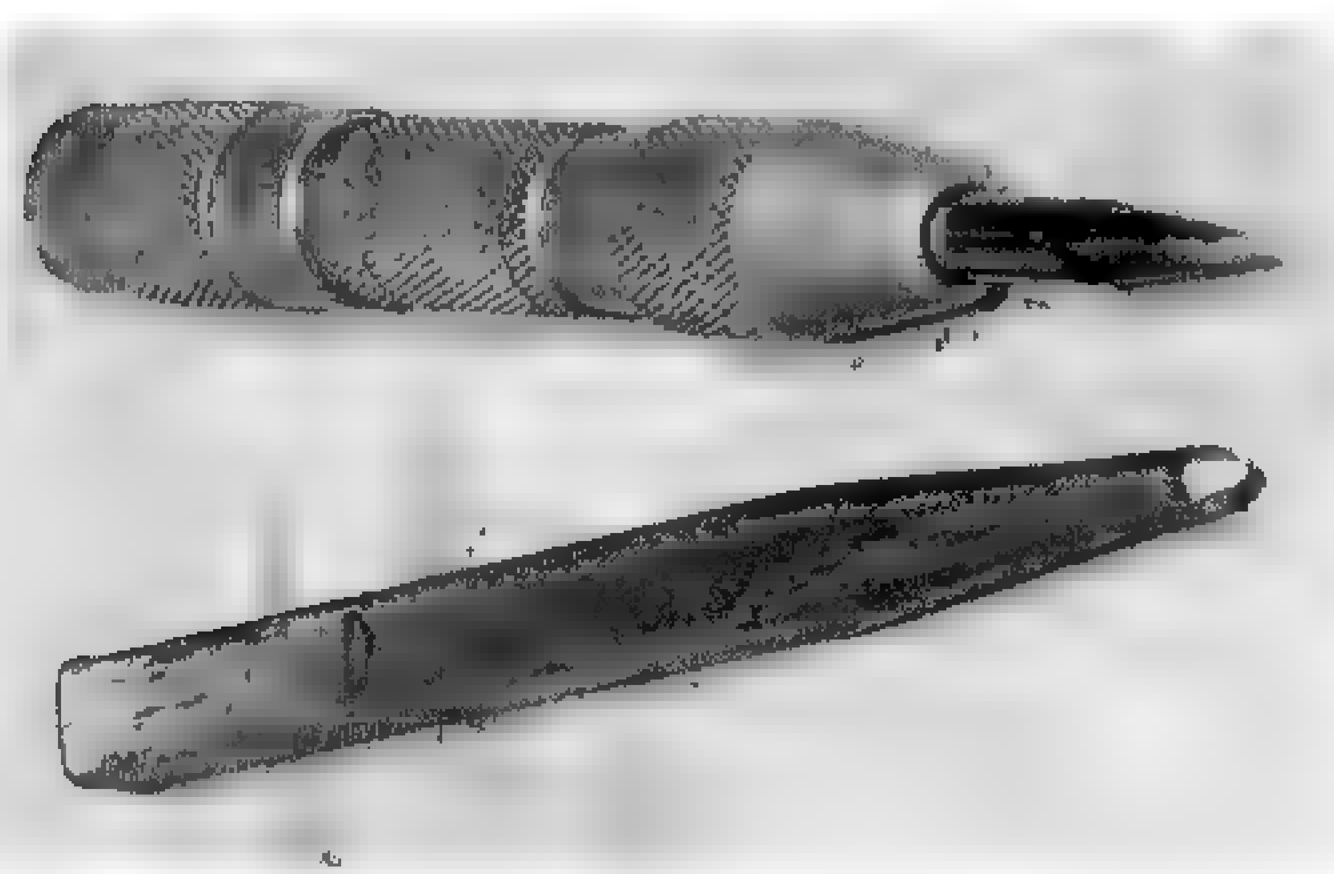


Figure 6.48 Manual and automatic center punches are useful. Both can be purchased at a local hardware store

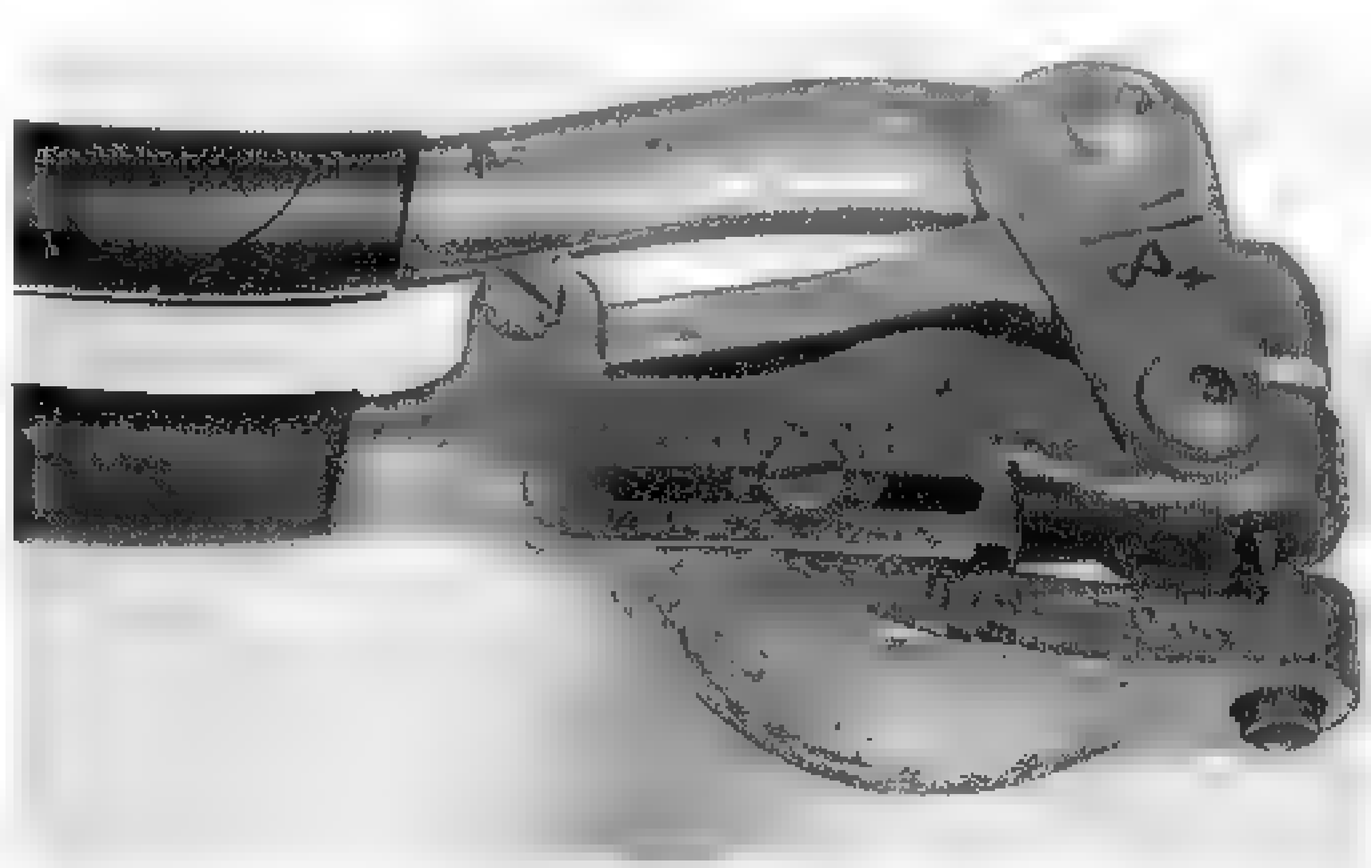


Figure 6.49. Hand punches are an attractive alternative to an electric drill for anything less than 12 gauge material

armourer without a Whitney hand punch will need a wide variety of bits, especially in the 1/8, 5/32, 3/16, and 1/4 inch sizes. Several bits in each size should be kept on hand because they *will* break at the wrong time.

Cutting fluid should be used in conjunction with any drilling operation in metal. This serves to keep the bit cool, which maintains its hardness and keeps it sharper longer.

Whitney Punches

Alongside the drill, the small hand punches manufactured by the Roper Whitney Company of Rockford, Illinois, will be in constant use. Of their product offerings, the #5 Roper Whitney Junior Punch (fig. 6.49) will penetrate as much as 14 gauge steel. These small punches feature a die set for each size from 1/16, 1/8, 5/32, 3/16, 9/32, and 1/4 inch. Extra dies can be purchased from many suppliers—it is prudent to keep the key sizes on hand at all times. Usually the punches are bought new, as they are inexpensive and difficult to find secondhand. Because of the low cost, several armourers have purchased four or five of the Junior punches and keep a different size die in each one so that they don't have to change dies in the middle of a project.

Flea markets and some tool supply houses sell imitation Whitneys made in the Far East. These punches are cast from inferior metal and generally fail quickly. It pays to get the real thing—they will last a decade or more with minimal care.

When using the punch, steady, constant pressure should be used; jerky motions threaten to break the dies. Never try to hammer the punch closed because the dies will almost certainly break under the shock of a blow.

In addition to the #5 Junior Punch, the Roper Whitney Company makes a variety of larger sheet metal punches operable both by hand and hydraulic power. The #3 punch is especially useful for piercing holes in heavier gauge metal (such as the 12 gauge steel often used on tournament helmets). For the larger punch, a 3/16 inch die will prove most useful.

JOINERY AND ARTICULATION

After the pieces have been formed, various tools will be needed to assist with joinery and articulation.

Plates are combined into larger surfaces and joints through articulation, riveting, and welding. There is evidence to suggest that medieval armourers used forge-welds to construct cones and deep shapes such as helmet bowls. These welds were made by placing plates one atop the other and hammering them under intense heat to create a strong join. Helmets of riveted plates were popular until the 14th century. Plates were engineered to move smoothly, with little gap between them, on rivets in both stationary and sliding configurations.

Modern armourers have access to two elements of technology that make these processes easier. First, simple nuts and bolts hold small plates in place while the articulation is being developed. Second, gas and combination gas/arc welders make plate joinery far easier than it was for the medieval armourer. For the reenactor market, welded pieces are generally preferable because they can be completed in a fourth or fifth of the time that a comparable piece can be done from a single piece of steel. For the finest work, however, the piece should be done without recourse to constructed technique, in which case the torch is still extremely useful for annealing the metal and accomplishing basic hardening.

Medieval manuscripts show the forge as a central element of every armourer's workshop. Hot-raising and heat-treating were critical skills possessed by the armourer of the Middle Ages, though most novice and intermediate armourers make do working metal cold and using a torch for the hot work and necessary joinery.

Lead Block

A basic tool for the armourer is a simple block of lead. This is used primarily for setting rivets without damaging the rivet head (in lieu of a rivet set) and also for forming small components such as finger gauntlet gatlings,

thumb tips, and mitten gauntlet lames. Blocks from 3 to 20 pounds are useful.

Lead can be melted on a stove in a double boiler and poured into a rectangular pan to make a large, flat block. When the block is no longer useful, it can be remelted and reused. Never touch a lead block with bare skin, as lead toxicity can build up in the body. After working with lead in any capacity, wash your hands and face immediately and thoroughly.

Rivet Set

Commercial rivet sets are simply small blocks of steel that have a dome useful for setting the head of the rivet while the opposite side is being piened. They are inexpensive and easily found both new and used.

Riveting Hammers

The finest riveting hammer I have seen is a simple, very small ball-pien hammer of extremely dense Swedish steel. The density of this hammer makes piening rivets a joy since each blow transmits much more force to the rivet. Beyond this, various long-necked hammers are useful for piening rivets where a smaller hammer cannot reach.

End Clippers

To cut rivets, metal clippers will prove useful (fig. 6.55). The best of these for armouring purposes seem to be made by the Crescent Company, because the blades are tough but thin, making for a good cut without as much burr as will be left by competitors' clippers. One model has a recurved handle useful for cutting extra-large rivets.

Welding Equipment

Oxyacetylene—a combination of burning gases run through a torch—is the most commonly used form of welding amongst armourers. Where barstock is used a great deal, heli-arc or arc welds are also found. The advantage to oxyacetylene is the certainty that the weld has fully penetrated the metal.

FINISHING TOOLS

Once the plates are formed, smoothed, fitted, articulated, and possibly heat-treated, the finishing tools will be brought to bear. In the Middle Ages there are records that indicate that work from the hammer was given over to other specialists for finish and polishing, although there is no detail to say at what point this happened. The supposition by most armourers I know is that work was supplied planished from the hammer because munitions-grade armour was often sold directly from the hammer (at least during the 16th century).

The medieval craftsman seemed to use large water wheels to polish the iron and steel. These wheels likely turned very slowly and were coated with leather and some sort of abrasive, possibly fine sand, affixed with a gum.

Figure 6.50 Larger versions of the hand punch are excellent for piercing thicker material and for use with special dies like those shown in Figure 6.51

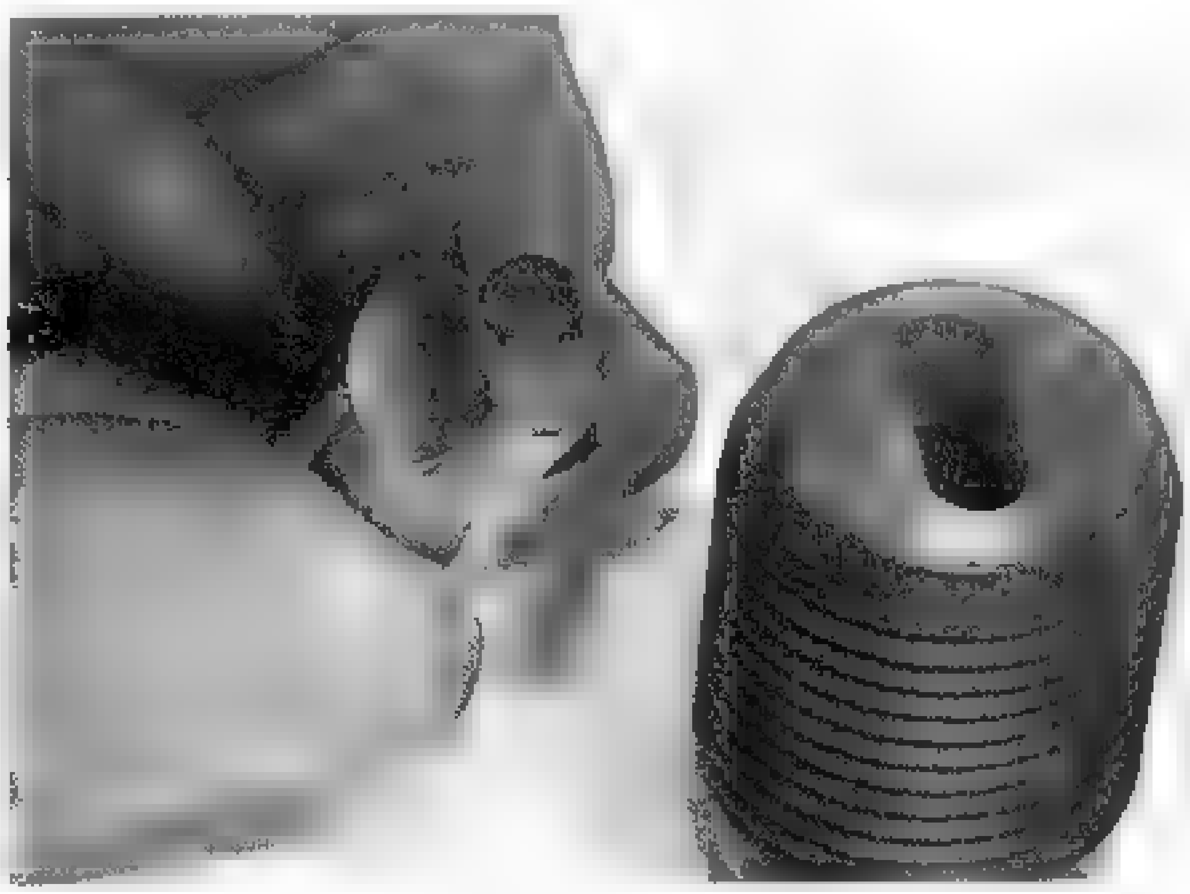


Figure 6.51. Custom dies for the larger hand punches make short work of some shapes like the oval, useful for doing production level sliding rivets

Modern polishing is little different save for the power source and the speed of the motor. Hand files are used for very fine work, for occularia, and sometimes for creases. On the higher quality pieces, the hammered work can be finished with a fine file and then polished by hand with emery paper. This technique imparts an attractive dark gray finish to the piece that approximates what we believe to have been present on many medieval examples.

There is evidence, however, that the finer medieval harnesses were finished to a mirror polish. In the Madonna de la Gratze chapel in northern Italy, several full Milanese harnesses were discovered during the early part of the 20th century, still *in situ* where they had been at rest since the 15th century. When the helmets were disassembled, the polish on their bowls had been protected under the brow reinforce,

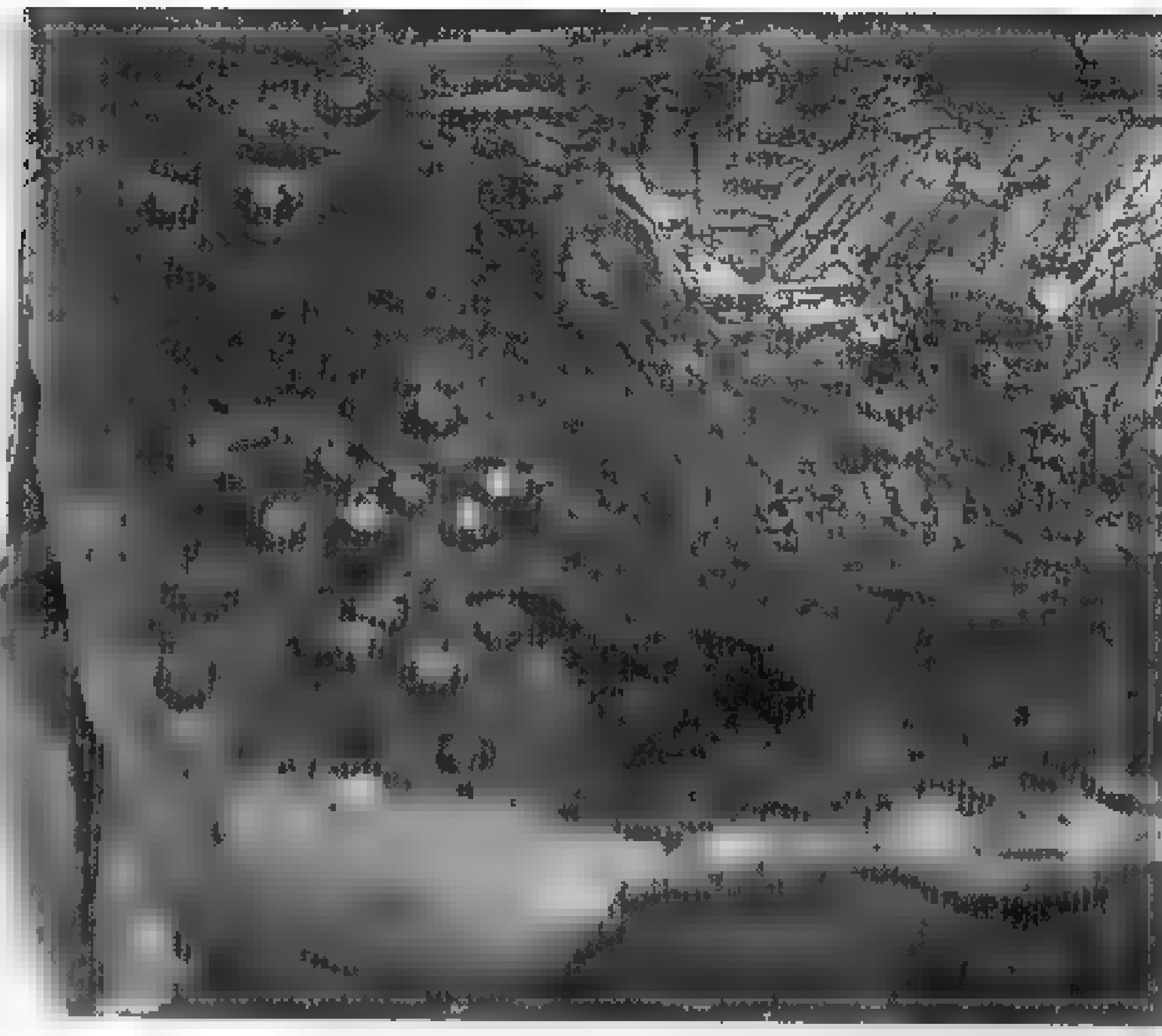


Figure 6.53. A lead block is an excellent multipurpose forming tool useful for riveting, making impromptu forms for small pieces, and holding other tools in place. Care should be used when working with lead to avoid exposure, as it is toxic

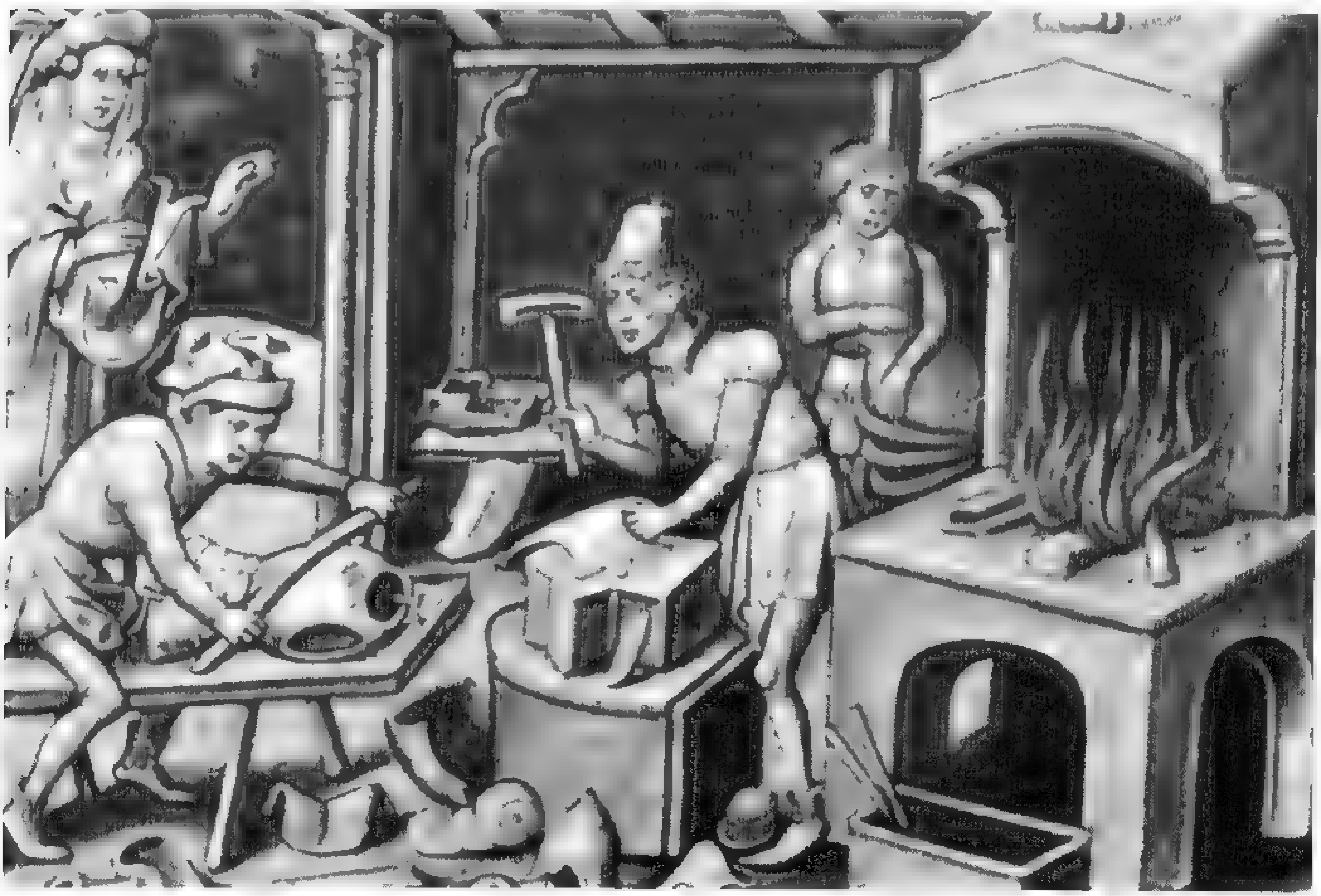


Figure 6.52. The forge was a central element of every armourer's workshop, though only a few modern armourers use them regularly. Skilled use of hot working and raising is essential to mastery of the armourer's art as illustrated in this grisaille by Guillaume Vreland. (Photo courtesy of Universitaltsbibliothek Erlangen, Nuremberg, Germany.)

maintaining a mirror polish. Most pieces in modern museums have been refinished many times in the three to five centuries since they were made, so it is nearly impossible to draw conclusions from museum examples.

The modern armourer can make use of a bewildering array of sanding systems ranging from hand-held sanders and grinders to more powerful end and belt sanders. Most sanding, however, can be accomplished by the same motor that the polishing wheels exist on, allowing the novice to invest once in a good motor and use it as two tools.

Files

A minimum of two files will be needed by the novice armourer, a "bastard," or rough file, and a "mill," or fine file. Each should have a flat and a rounded edge, and the teeth should be able to cut. As files are used, the teeth become clogged, bent, and worn away, reducing the effectiveness of the tool to the point of uselessness. Files acquired secondhand are frequently in this state, although good ones can also be found if you look carefully.

For more advanced work, a larger variety of files will prove indispensable. Large and small versions of both roughnesses will all find uses, as will round, square, diamond-shaped, and others. Jewelers' files are also useful for detail work where control is highly valued, as in latches, eyeslots, and filed details.

Sandpapers

For finishing the better pieces, emery paper in fine, medium, and coarse grades along with a flexible sanding block should be kept on hand for the satin finish mentioned above. Old sanding belts are often good for rough work.

Grinders

For removing welds, a hand-grinder such as is commonly used in auto body shops will prove useful. These are available in multiple sizes. Small ones are made by Makita or Milwaukee and larger ones by a handful of electric tool manufacturers. These grinders tend to throw many sparks because they take metal down rapidly and so should be used only with heavy gloves, goggles, and a dust mask. Use the grinder to quickly remove extra material from welded joins.

Abrasive Disks

Available as flat aluminum oxide disks in 7 1/2 and 9 inch sizes, each featuring a central hole, these disks are used on a polishing motor alongside of a buffing wheel to serve as an efficient, low-cost, but very effective alternative to the dedicated belt sander. They should be purchased in 50 and 100 or 120 grits. The wheels themselves are normally used on disk sanders, generally for paint removal, and are available from any hardware store or abrasive supply house.

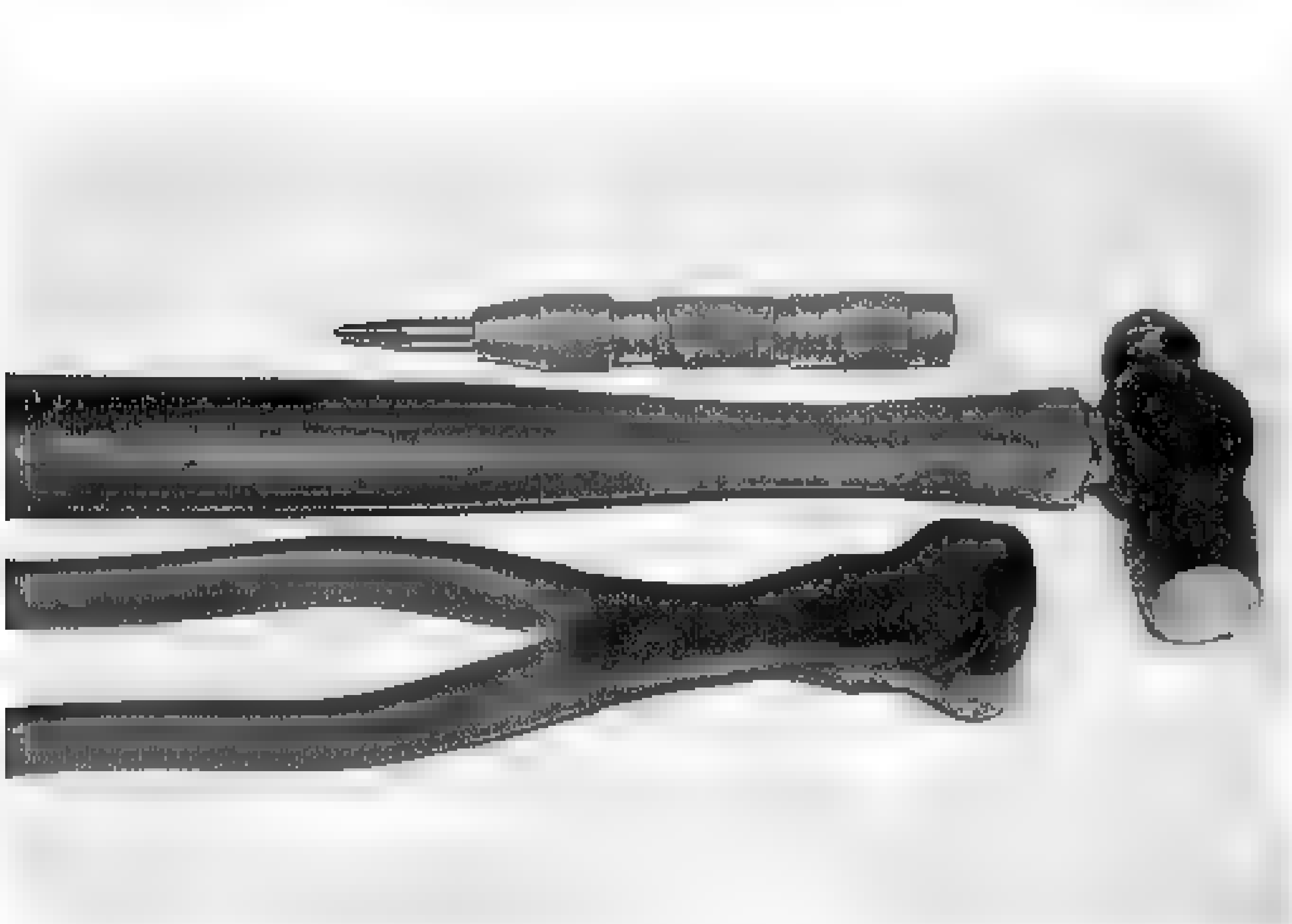


Figure 6.54 Various tools are useful for the riveting process. Top to bottom: an automatic center punch, riveting hammer, and end clippers

Figure 6.55. End clippers, such as these produced by Crescent Tool, are excellent for clipping rivets. The recurved handle allows for extra leverage.

Belt Sanders

Without a doubt, the finest tool for all-around finishing operations is the flexible-back belt sander. Originally a tool used extensively in knife making, the premier model is the Burr-King (although I have recently received word that the company has gone out of business). This powerful pedestal-mounted unit uses efficient 2 x 72 inch belts, an 8 inch lower contact wheel for aggressive stock removal, and a long 24 inch segment where the belt runs free of any backing. This "flexible back" provides an extremely subtle and accurate way to sand creases and large globed surfaces and to work edges or grind tools.

The belts themselves are available from many places and should be purchased in 50 and 100 grits. Stock up on these—they will never be wasted

Figure 6.56. The modern and medieval armourer both make frequent use of files for edge and even surface finishing. The shop cannot have too many files. Because of the high quality of their steel composition, they can be modified to make other tools after they've worn out

Polishing Motors

Most final finishing and sanding operations can be done with a single, mounted 1 1/2 to 2 horsepower motor that spins at 3250 RPM. Sealed motor housings are preferable because they resist damage from dust and polishing debris, but they are more expensive.

Motors can be obtained new or from any of the secondhand sources mentioned above. New motors can be purchased from electric supply houses, where they will also, for a fee, mount it and add a heavy-duty switch. The motor should be on a heavy-duty circuit rated for the motor's amperage under load, because the armourer will tend to lean into it in an effort to make the sanding or buffing cut faster. If too many electrical appliances share the circuit, then blown breakers are a common—and dangerous—occurrence.

The motor should be mounted solidly on a pedestal or other table where the shaft extends outward as much as possible. Armourers will attempt to work on many large pieces of metal, and the stand should interfere as little as possible with the free movement of a piece around the arbor. The arbor itself, along with buffing wheels and compound, can be purchased from specially knife-making supply houses or from better hardware stores. Arbors are held in place usually by two set screws that are tightened to the motor shaft. The arbor has a threaded shaft that extends the length of the motor's shaft and allows wheels to be held in place with nuts and sturdy washers.

Some armourers have professional polishing motors, often made by Baldor Manufacturing. These are fine systems, packing horsepower ranges from 1/2 to 5 hp, though they often require a 220 volt power source for the higher horse motors. These are excellent if they can be acquired used, but I have found a regular, sealed motor just as effective and far less expensive.

Polishing Wheels and Compounds

Dense polishing wheels of felt or close-sewn muslin speed polishing operations using traditional compounds. Some wheels are available at better hardware stores, but they are expensive and do not compare in quality

to those found at specialty knife-making supply houses.

Wheels should ideally be 8 to 10 inches in diameter, forming a buffing surface at least 1 inch wide. Two 1/2 inch wheels can be used side to side, or a single 1 inch wheel can be obtained. The better wheels are much more expensive than their hardware store cousins, but they last far longer, take more abuse, and cut polishing time dramatically.

A novice armourer will need two wheels at a minimum: one for the rough polish accomplished with greaseless or setup compound, and another for high-finish "white" compound. If possible, four to ten such wheels should be used so that they can be rotated. This will reduce the waiting time necessary to wait while greaseless or setup wheels harden sufficiently to use.

There are several options for polishing compounds, though the "greaseless" compounds supplied by knife-finishing houses or Formax Manufacturing are by far and away the most popular for their versatility, power, and low cost.

Greaseless compound comes in paste tubes. The normal variety, a very rough red compound with a distinctive smell, comes from Formax looking very much like a tube of sausage. It is applied to a wheel and allowed to dry; it then becomes a mild abrasive capable of removing light sanding marks. Most armourers

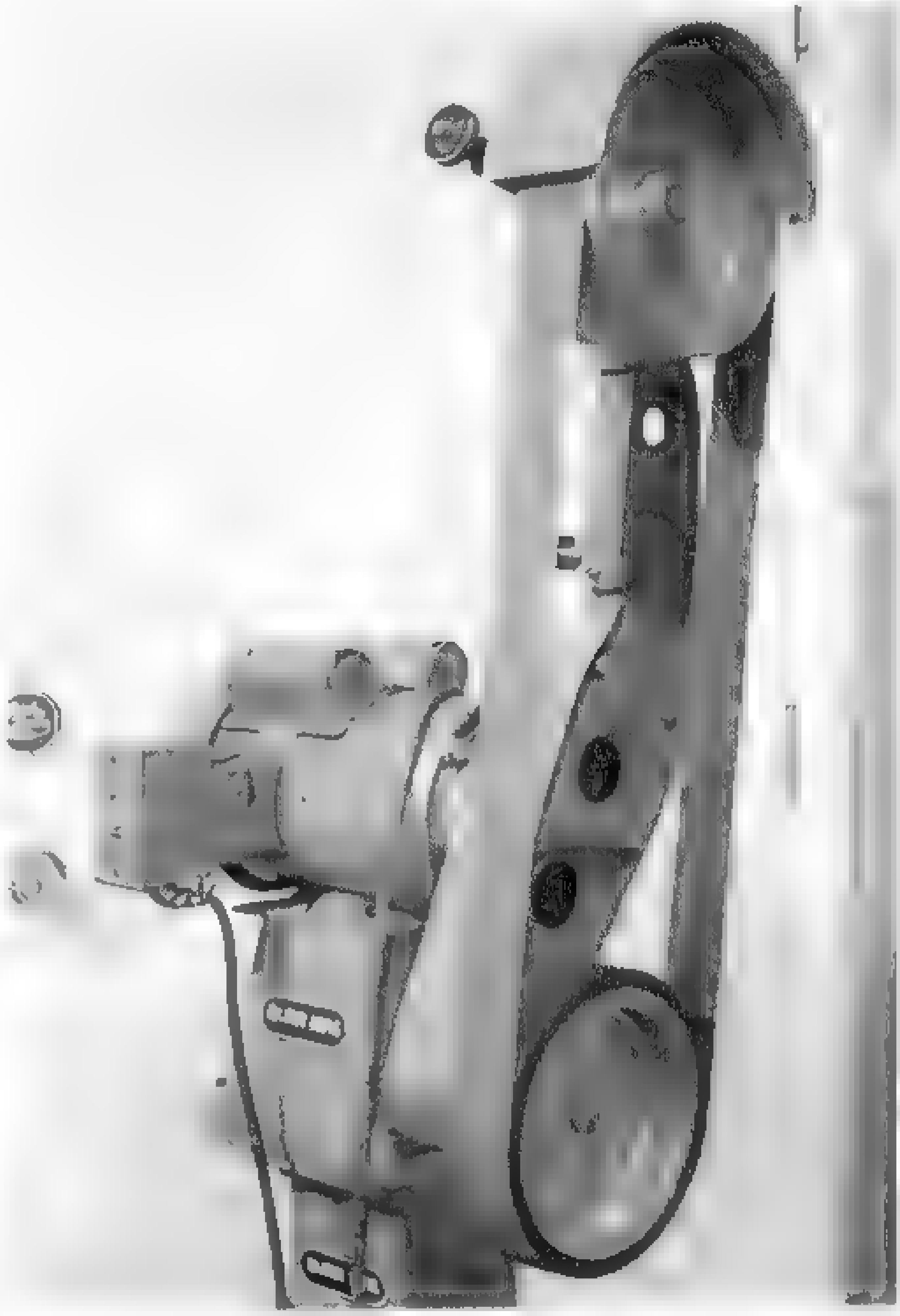


Figure 6.58. A belt sander such as the Burr-King can be an armourer's most used tool. Although there are a host of competing models on the market, I have used the same Burr-King unit for more than 10 years and it has held up to substantial abuse from a multitude of armouring students.

Figure 6.57. Sanding disks and polishing wheels can both be used with a simple polishing motor to achieve a high-quality finishing setup with minimal cost.

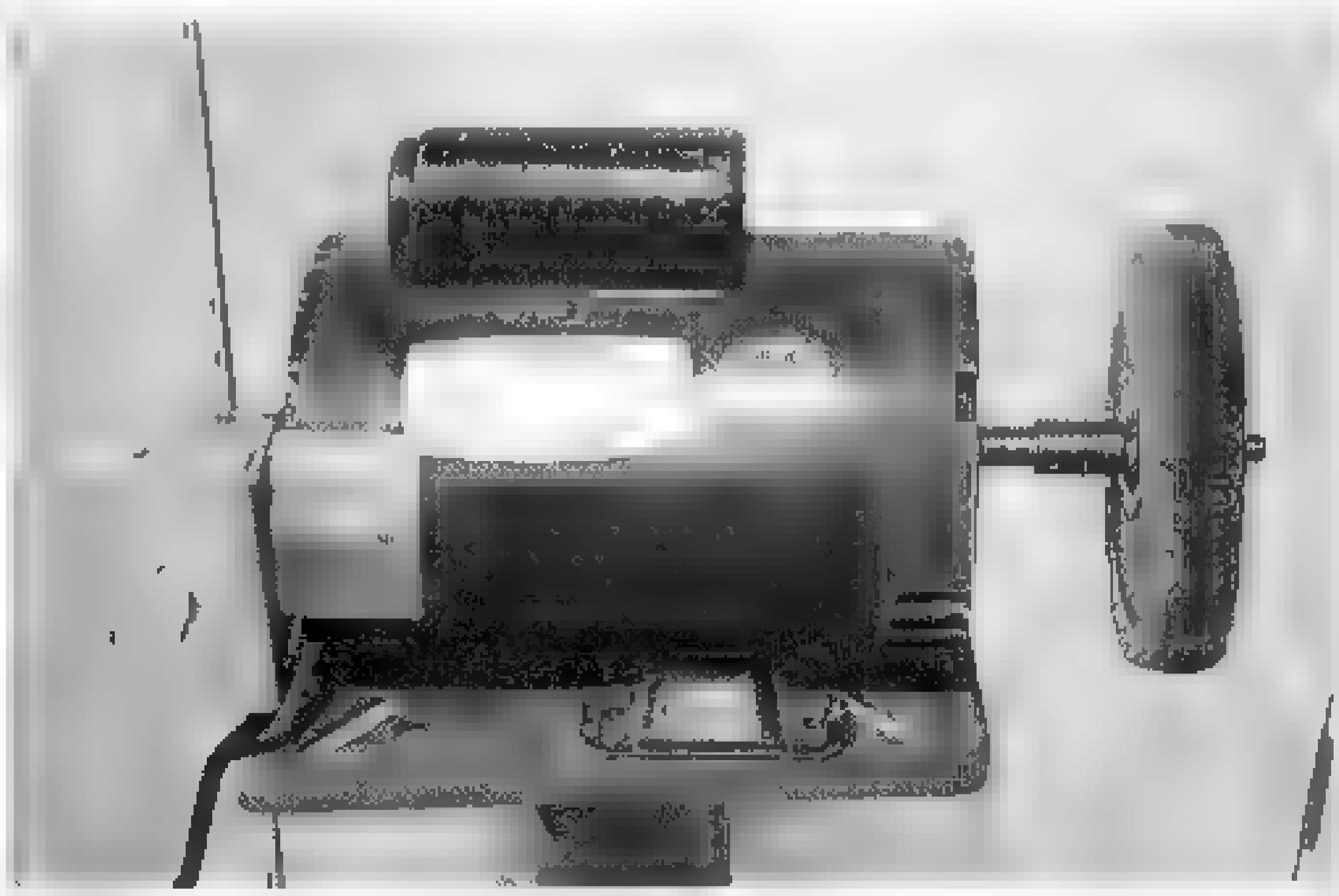


Figure 6.59. A simple motor mounted on an inexpensive pedestal makes an ideal polishing/grinding platform. Use a 1 1/2 or 2 horsepower motor as a minimum and attach a commercial arbor (available from many hardware stores for about $5).

use this compound following finish sanding, moving directly to the grease-based compounds to bring out the brightest finish.

Set Wheels

A newer alternative to greaseless compound, whose debris and dust can make the polishing area a forbidding place, is to use a "set" compound. This brush-on abrasive is available either from knife-making supply houses or from Formax Manufacturing. Lasting far longer than the grease-based compounds, the abrasive comes in a liquid state. It is first well stirred, then brushed on the wheel and allowed to dry for from 5 to 12 hours. A well-charged wheel can be used for several hours so long as it isn't caught on the edges or over holes. Set wheels are more expensive than greaseless compound and require more planning to use, but the savings in reduced dust alone make them an interesting alternative

Scotch-Brite Wheels

The most expensive alternative to the greaseless or set wheel are the "Scotch-Brite" wheels made by the 3M company. These wheels, which take the place of the muslin wheel, contain the same sort of synthetic abrasive found in the green pads used to clean dishes. They yield a very even polish without charging, but they do tend to disintegrate when they

Inventory References to Armourer's Tools

Below are some inventory references to armourers tools from the 14th, 15th, and 16th centuries. See the endnotes for the source of each citation.

Anvils
ij maides[2]
one andevyle[6]
Anchundine a 1° chorno rotta[8]

Stakes
ij bicorn[1]
j bequerne[5]
a great bekehorne[6]
a smalle bekehorne[6]
a pype stake[6]
a creste stake[6]
a vysure stake[6]
a hanging pype stake[6]
a stake for the hedde pecys[6]
ii curace stakes[6]
a harsh stake[6]

Shears
iiij instrumenta ferrea ad claves inficiendos[3]
j cottyngyre[5]
iv peyre of sherys[6]
92 libere di ciesoie salde da tagliare (92-lb "strong" shear)[8]
iii paia di lanciatoi dh maglie (hand sheears)[8]

Hammers
iij slegges[4]
iiij hammeres[4]
Item, hamer[5]
iii platynge hamers[6]
a creste hamer for the hedde peces[6]
ii hamers[6]
ii greve hamers[6]
a meeke hamer[6]
ii pleyne harners[6]
ii platyuge hamers[6]
a creste hamer for the curace[6]
ii rewetinge hamers[6]
1 boos hamer[6]

Misc.
a vyce[6]
xi ffylys[6]
a payre of pynsors[6]
ii payre of tongs[6]
ii chesels & vi ponchons[6]
a watr trowgh[6]
a temperinge barrelle[6]
a pyare of pynsores[7]
a payre of nyppers[7]
4 crest fylys[8]
ii chalami di piombo (lead quills for marking)[8]

catch an edge. And they are expensive. But there is no better way to get a very even satin polish on metals such as stainless. If you are using the belt sander, there are even 2 x 72 inch belts available in several grits.

White or Green Stainless Compound

If you desire a "white" or the highest polish available, a stainless compound is used to work beyond the satin provided by the greaseless variety. A special wheel should be used for this compound alone. It is reasonably easy to find—most hardware stores have some version of the white compound, and jewelry supply houses often are familiar with Zan, a similar product.

LEATHER TOOLS

While an armourer is generally not known for his leatherwork, a certain amount of leatherworking tools must be acquired to enable him to do strapping, linings, and floating articulations.

Leather Shears

All leather must be cut. Specialty leather shears, basically a special sort of scissors, provide excellent cutting for leather of light or moderate thicknesses. Such shears should never be used on paper, cardboard, or other materials, as the angle of the edge is optimized for use on leather. They should be kept sharp. If these shears cannot be found, regular scissors can be used on light or some medium grades of leather.

Knives

Medium or heavy leather should be cut with a conventional box knife or a band saw. Box knives are frequently found in miscellaneous boxes of tools at auction or can be had for a few dollars at any hardware store.

Edgers

Once cut, the edge of the leather should be removed with an edger. This handy tool can be found at most leather supply houses such as Tandy Leather for a very reasonable price.

Strap Cutter

Although straps can easily be cut with a thick metal straight edge such as a carpenter's square, they can also be cut efficiently and accurately with a commercial strap cutter. These are available inexpensively from leather supply houses, along with extra blades. Extra blades should always be kept on hand and replaced whenever the leather begins to feel difficult to cut.

Strap Tip Cutter

Available from leather supply houses, these handy stamps are used to give a perfect cut on the strap end, an important finishing detail often overlooked by intermediate armourers. Like all leather punches, they should only be used on special cutting mats of Teflon, Kydex, or soft wood end grains.

Rotary Punch

In order to punch holes in leather, a good quality rotary punch should be acquired. A good one can be easily distinguished from its inexpensive counterpart by both price and weight. Inexpensive copies are often available from tool houses, leather supply houses, and flea markets, but they generally wear out after minimal use and should be avoided unless the armourer intends to make only a few pieces.

Straight Punch

An alternative to the rotary punch, good for production work and generally just to have on

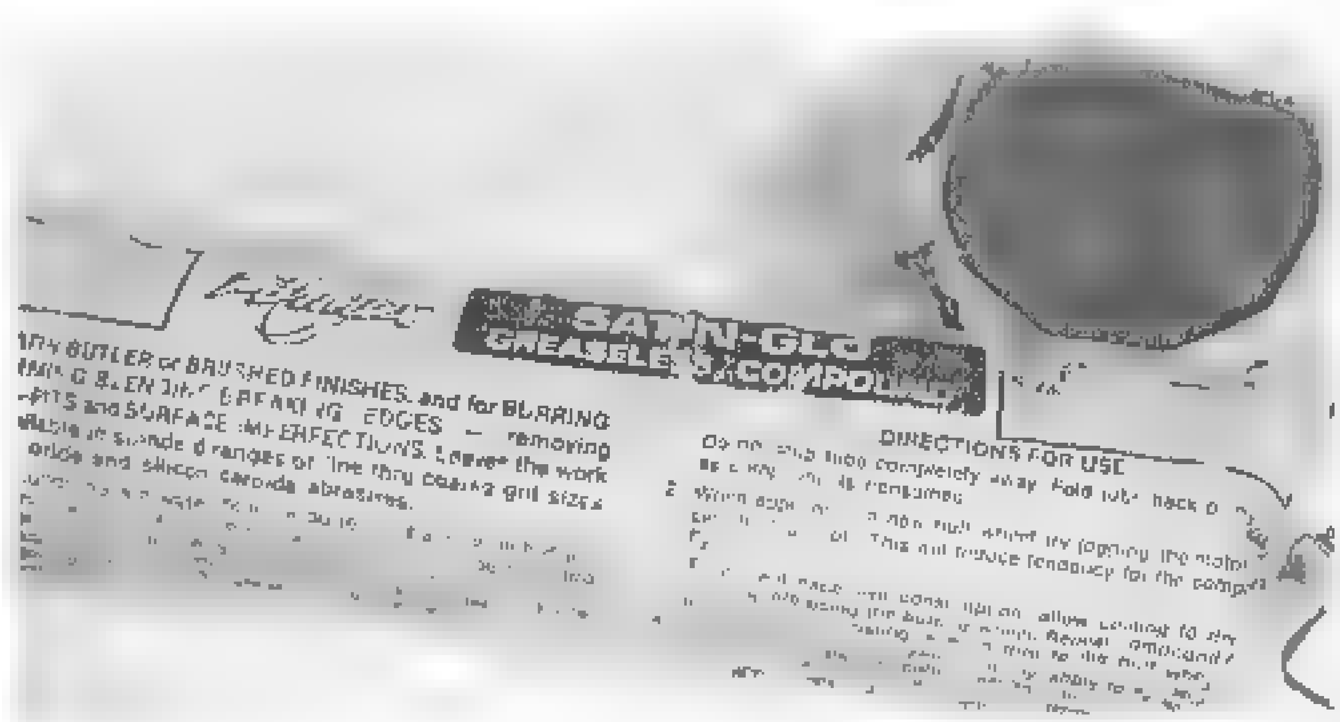


Figure 6 60. Greaseless compound such as in the tube above or the set wheel compound in the can are used to polish metal fresh from the sanding wheels or belts, providing finishes from smooth satin through a high gloss.

hand, straight punches are available either in fixed sizes or with interchangeable dies.

Oval Punch

Often underestimated, the acquisition of oval punches in the appropriate sizes will save hours of work for strapping even a single harness.

Stitching Punch

For leather stitching, leather supply houses often sell these singly. Use them to make many holes precisely the same distance apart. They are generally useful tools, inexpensive, and nearly indestructible.

Needles and Waxed Thread

A variety of needles and waxed thread are immensely useful for stitching helmet liners, making shoes, and affixing buckles. Heavy linen thread is preferred, if it can be found. Synthetic waxed thread is more commonly available, usually from craft or leather supply houses.

ENDNOTES

1 "Quills of lead." Presented in a paper "1429: The Last Will and Testament of Giovanni d'Andrea a Florentine Armourer." Giovanni had two of them in his home when he died, probably surplus from his "complete workshop" listed at another location (but unfortunately not detailed).
2 Accounts of the Constable of Dover Tower, 20 December, 17 Edward III, 1344.
3 "1429 Inventory of Giovanni di Andrea of Florence.' Unpublished paper delivered at the December 1998 Wallace Collection study day by Christopher Dobson
4 Accounts of the Constable of Dover Tower, 26 January, 35 Edward III, 1369.
5 Inventory under the Privy Seal of Henry VI, 1485
6 Payments made to John Blewbery, armourer to Henry VIII, 18 September, 1514.
7 Equippage of Henry, Earl of Northumberland, 1513.
8 Record office for 9 July, John Blewbery, 1514.

Figure 6 61 The armourer will require a variety of leather tools for strapping Fortunately these can usually still be purchased from suppliers for the leather craft and shoe making industries

Chapter

Supplies for the Armoury

In addition to tooling, every armourer will consume quantities of steel, rivets and other fasteners, and leather. Contemporary materials are not, unfortunately, precisely the same as the medieval originals. Steels are far more homogenous in their alloying, are of an even thickness, and are free from slag. Modern rivets are far more precise than the originals, made in machines rather than by a specialized craftsman or junior armourer. Leather is often tanned using mineral oils rather than vegetable oils preferred by medieval tanners. The novice or intermediate armourer should not worry too much about this disparity, but it is instructive to be aware of the variances so that as he progresses, more authentic materials can be sought.

METAL

Every armoury requires metal. Although medieval armourers—at least prior to the late 15th century—generally used sheet iron rather than steel, modern armourers usually work in mild steel cold- or hot-rolled. Often the metals used in the modern armoury are slightly heavier than their medieval counterparts because many of the tournament societies such as the SCA have well defined regulations governing

Opposite page.
Figure 7.1. A host of supplies used by the armourer: leather, sheet steel, rivets, arming nails, waxed linen cord, and needles

component thicknesses. For the better pieces, medium- or high-carbon steels are often used. Some armourers even use stainless steels.

Steel

Broadly speaking, steel can be acquired new or surplus. The primary advantage to using new steel—steel purchased as a particular grade from a commercial dealer—is that you know what you are getting. Additionally, dealers have large shears that cut the steel into manageable pieces. I prefer 3 x 2 or 2 x 2 foot sections (but use care—some patterns for breastplates are *larger* than 2 x 2!). To find a steel dealer near you, look in the yellow pages under "metal" or "steel."

Steel can also be acquired surplus from scrapyards or sometimes from sheet metal shops. The price is generally very low at a scrapyard, but the composition of the steel is often unknown. While not a heavy constraint for general or display work, if any kind of heat-treating or welding must be done, not knowing the composition can be problematic. From sheet metal shops the source is often known, and a friendly shop may offer to sell you stacks of scrap at a very good price that you can turn into elements of a harness.

Low-Carbon Steels

Low-carbon steels, both hot- and cold-rolled, are inexpensive and plentiful. They possess the virtue of being uniform in the distribution of carbon and trace minerals, making them an excellent choice for most armouring projects both for reenactment and collections. Low-carbon steels can be found in any city from any sheet metal supplier. Most armourers work in 20, 18, 16, 14, and sometimes 12 gauge. Those working for reenactors tend to prefer the thicker gauges, while those working primarily for collectors lean toward the thinner.

Medium- and High-Carbon Steels

Medium steels in the 1050–1070 range are more difficult to obtain, but they enable the armourer to heat-treat and possibly temper his work as well. Spring steel sheets are sometimes available, but they cost 5 to 25 times the price of low-carbon steels. In order for the benefits to be realized, however, the armourer must have access to heat-treating facilities, consisting of at minimum an oxyacetylene rig or a large kiln.

For special, very small plates, the spring-steel ribbon used to secure pallets can be utilized. Lames on finger gauntlets and spring catches inside of helmets can be made from this readily available material, which is often salvageable from lumberyards and shipping companies.

Stainless Steels

Some reenactors prefer their equipment to be made from stainless steel, so-called because the presence of chromium and other trace minerals reduces the oxidation. While such

Figure 7 2. Dome and truss-headed rivets are the most useful commercial rivets to the armourer. Both should be obtained in 1/8 and 3/16 inch diameters They are available in both brass and steel. Common 8d box nails and roofing nails are very useful "arming nayles" for leather-to-steel attachments

harnesses are much easier to maintain, they are difficult to work because the steel tends to defeat the hardness of punches, stakes, and even hammers, plus it requires special welding equipment. The polish on stainless steel also tends to look artificial because it has a much greater "white" quality then do other carbon steels. Because of the added difficulty, harnesses rendered in stainless generally cost from two to four times more than a similar harness in low- or medium-carbon steel.

Stainless steels, bearing a wide variety of alloyed metals in addition to the chromium, are very difficult to identify and thus should usually be acquired from a knowledgeable dealer. It can be found surplus, but these sheets should only be used for pieces where no welding is required.

Barstock

If an armourer produces harnesses for the reenactor market, various sorts of barstock steel will be required for sword hilts and helmet grilles. Use special care when selecting barstock from a surplus dealer—composition varies wildly, and in most cases it is intended for use as a grille defending the head or hand. Some compositions of barstock don't weld well and are brittle.

Some square or rectangular stock should be kept on hand for the manufacture of ad-hoc tools. Medium or tool steel works extremely well if it can be acquired.

Brass, Bronze

For armour of the 14th century, brass and bronze are extremely useful. During the transition such metals were called "latten," and it was used as one of the experimental materials throughout the century.

Brass is far easier to find in the United States than is bronze. Any metal supply house will have sheet brass, while bronze must be obtained from specialty supply houses (several are listed in Appendix C). Brass, an alloy primarily of copper and zinc, is a favored material in modern decor. Bronze sheet, used primarily by professional architects, is very difficult to obtain, although it is a superior metal for hammer forming because it hammer-hardens more slowly than does brass and polishes to a much richer color

HARDWARE

Every armoury needs to be well-stocked with rivets, bolts, washers, and hinges.

Rivets

Medieval accounts frequently listed "arming nails" instead of rivets. We do not know, precisely, what these nails were, but by a happy coincidence modern nails work extremely well as rivets in many applications. Since very flat-headed rivets are hard to find, nails will perform well for general use.

Rivets for Metal-to-Metal Work

The most common rivet used for metal-to-metal work is the round-headed 3/16 inch rivet available from most better hardware stores. These can be difficult to cut with hand clippers, however, and the sizes commonly available are too long for most armour work. With some effort, you can find some that are 1/4 inch long; these are the perfect length for articulation of plates and assembling sheet steel parts. These should be used wherever joints are articulated, as other rivets are too small to provide adequate support. Brass, stainless steel, and low-carbon hot-rolled varieties are available.

There is a smaller size of round-head rivet sometimes available from hardware stores, the 1/8-inch-diameter round-head. These are only suitable for light work or, when many are used in close proximity, for medium duty. They are commonly available in brass or steel.

Another common rivet good for general assembly is the 3/16 inch flat-headed rivet. These are generally 3/8 or 1/2 inch in length, which means they have to be cut for most applications, but they can do the job. Use these when you don't want a round head on the outside, such as when assembling some types of helmets. Generally the round-headed variety are far more useful. I have seen these mostly in steel but occasionally in brass.

Truss-headed rivets are a mix between the flat and round heads. They have limited historical value but can serve as surrogates for any of the above applications.

Common 8d box nails are good to keep around for gauntlets and other light work. They are inexpensive and very useful in the construction of fingertips.

Rivets for Leather-to-Metal Work

A supply of roofing nails will serve well when attaching leather to steel. The head of the nail is set on the leather side, and the nail is clipped with end clippers and piened against the metal surface. Boxes of roofing nails are extremely inexpensive. Beware of nails that have excessive flashing at the tip or the base; at the tip it will be difficult to pass the rivet through the 5/32 inch hole in the steel, and at the head it will cut into the leather and reduce the life of the leather.

Rivets for Leather-to-Leather Work

For leather-on-leather work, copper harness rivets are the most durable. There is little, if any, evidence for their use on authentic medieval harnesses, so they should be used when absolute authenticity is not as great a concern.

Commercial two-piece "pop" rivets are commonly used for straps on reenactment harnesses. Because they are so easy to use and require no piening (you just hammer them flat), clipping, or modification, they have earned their other popular name, "speed" rivets.

Bolts

When engineering joints, bolts are an indispensable tool. I prefer 3/16 inch stainless steel bolts (they are harder than the mild-steel equivalent) that are 1/2 inch long and coarse-threaded. Matching nuts are used to keep the bolt in place while the location of other pivot points on the piece are being determined. A box of 100 is generally sufficient for a few years.

Hinges

For the better work, hinges should always be made by hand (see Chapter 21). For production work, however, 1 inch mild-steel hinges are commonly used. These can be had—sometimes—without holes, which allow for medieval designs to be filed into them. The plated hinges available in most hardware stores should be avoided because the plating looks very out of place on a satin or highly polished bit of armour, though it can be polished away.

LEATHER

Leather will be needed for strapping, interior leathers, and various elements of brigandine armour. It is measured in "ounces" by the industry. In many cities across the United States, leather can be obtained from Tandy Leather, although this is a far more expensive source than more specialized dealers (see Appendix C).

Choosing Leather

A supply of latigo or good quality tooling leather should be kept on hand for making straps, especially when the armour is intended for heavy use. In the restoration frenzy of the last century, many museums used suede or very light leather for straps. This leather is completely unsuitable for field use and would probably be rejected by medieval knights in favor of something heavier. Latigo can be found in black, a deep red, or brown, while tooling leather comes in the ubiquitous tan, ready for whatever finishes you need to apply.

Leather for straps can be cut out of a larger hide, or commercial straps can be purchased either from a supply house like Tandy or as reins from a saddlery shop. For interior leathers, such as those used on the arm harness, a plain undyed leather can be used. Care should be taken in this instance to choose leather that will remain supple yet possesses the strength to support the movement of plates over a long period of time without failure.

Commercially available leather thong is also adequate for use on brigandines and to field-repair a harness. Keep several lengths on hand and in the "armour repair kit" that should be carried to the field. (A typical kit will include a ball-pien hammer, a chunk of steel to act as an anvil, a rotary leather punch, leather

thong, precut straps, some leather scrap, scissors, buckles, and a variety of rivets.)

Buckles

Most leather elements such as straps are held in place with buckles of brass, bronze, or steel. While the better reproduction should be finished with hand-crafted buckles of steel or reproduction buckles purchased from reenactors, the majority of armours produced for reenactors are fitted with commercial buckles. Of these, solid brass buckles are the best choice. Most buckles are plated, and this plating tends to come off quickly under field conditions, giving a ragged look to an otherwise pleasant effort.

Leather Dye

To finish raw leather, a good quality dye should be used. Fiebings or Lincoln are the best labels. Keep a supply of black and red at the minimum.

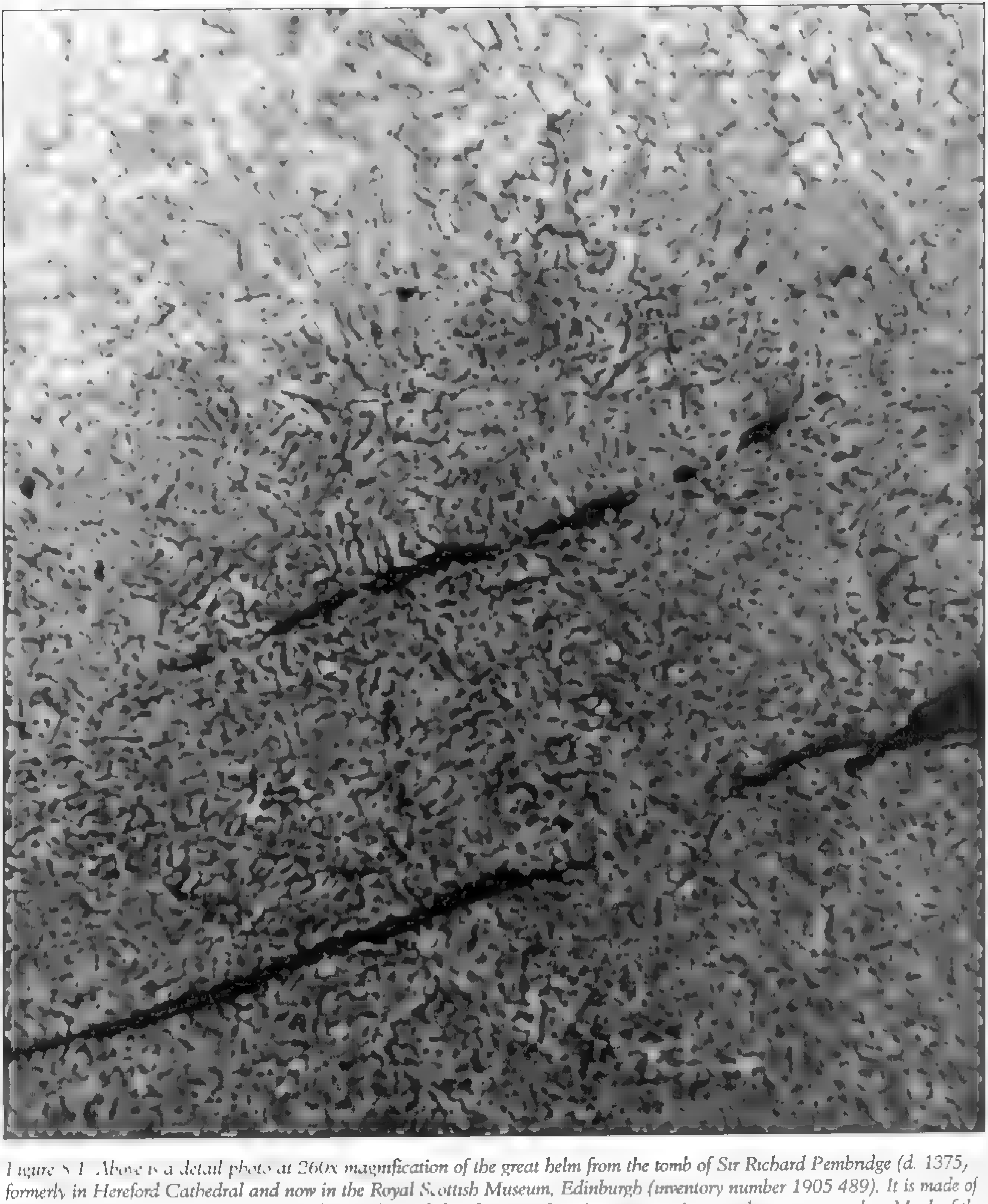


Figure 8.1 Above is a detail photo at 260x magnification of the great helm from the tomb of Sir Richard Pembridge (d. 1375), formerly in Hereford Cathedral and now in the Royal Scottish Museum, Edinburgh (inventory number 1905 489). It is made of three plates riveted together, not the five of the Bolzano helm (fig. 8.2). Its microstructure is somewhat more complex. Much of the section consists simply of ferrite and slag, but there is a band of martensite, corresponding to a layer about 1mm in thickness, on the outer side of the plate. Whether it was intentionally case-carburized is impossible to say with certainty (although the use of case carburizing of files is described by Theophilus in the 12th century), but it was certainly hardened deliberately by a full quench afterward. The average microhardness of the outer layer was 430 VPH (Vickers Pyramid Hardness, see Chapter 19, page 226) and that of the inner core was 110 VPH.

Chapter

Concerning the Selection of Metal:

Iron, Steel, and "Latten"

The medieval armourer inherited a limited technology relating to iron, steels, and the nonferrous metals. The industry of Rome had developed metalworking technology built on Hittite iron working until, by the 2nd century, Roman legions were using iron weapons and armour in the field against their bronze-wielding opponents. Rome's smelting and manufacturing capabilities created sheet iron in large enough pieces to build the famous *lorica segmentata* armours and mass-produced helmets that became the symbol of the legionnaire for centuries to come. With the fall of Rome, dimly recalled visions of Rome's style were copied and adapted throughout the old empire and beyond. But the ability to smelt and roll iron perished with the Empire—at least in so far as Europe was concerned, precious iron and steel were largely reserved for weapons.

"Dark Age" armourers used small bits of iron and copper alloys they referred to as "latten," along with mail and leather defenses, in place of the superior iron plate. They created defenses of brigandine and spangen construction to piece together larger defenses from small bits of material, crafting cunningly formed helmets and reinforced body defenses.

Iron, or "wrought iron," was the common material used by armourers from the 5th century B.C. until the

Opposite page. Figure 8.1. When viewed microscopically, the iron or steel used in armour can be analyzed to ascertain the composition, forming techniques (whether it was made hot or cold), and attempted heat-treatments

14th century. Formed through the direct reduction, or "bloomery," process, iron ore was heated to approximately 1150°C in a low, cylindrical furnace, where it was reduced to a spongy lump of iron and impurities known as slag. The uncontrolled nature of these impurities accounts for the varying qualities of wrought iron, control of which would not arise in Europe prior to the late 14th century.

Wrought iron by itself is soft and relatively easy to work, but because of this it is easy to damage. It can be transformed into steel in a process known as "case carburization" where the finished piece is packed in charcoal and heated for some hours. The process was known but barely understood by medieval metalworkers. Theophilus describes it as early as the 12th century,[1] but the vast majority of 14th century armour appears to be made from wrought iron, though interestingly they also appear to have been subject to some heat-treating. This is an interesting fact since heat-treating on wrought iron does not harden the material at all. It is for this reason that I hypothesize that case-carburization was perhaps used to infuse the outer layers of some armoured elements with carbon, a layer that, if thin, may have been worn away on extant pieces through five centuries of polish.

Steel, which is iron combined with varying degrees of carbon (from 0.1 to 0.9 percent), was largely unknown as a separate material until the 14th century. The amount of carbon and method of heat-treating determine the hardness and brittleness of steel. Through the research of A.R. Williams and Theodore Monnich, it appears that it was not until the 15th century that hardening and carburizing techniques became widely known, but even then they were expensive and carried out only on the finest armours.

MODERN STEELS

Medieval armourers probably procured their sheet irons and steels from craftsmen specializing in its production. The billets were created through bloomery furnaces that smelted the iron ore, creating an unevenly mixed but satisfactory alloy of iron ore, slag, some carbon, and other trace elements. The billets were hammered roughly into sheet form with very large mallets, yielding pieces that were not quite even in thickness or composition.

Modern steels are rolled in large mills after they have been thoroughly smelted or remelted, all slag removed, and amounts of trace elements added as necessary to achieve the desired composition. Sheet iron as used by the armourer of the 14th century is all but unavailable today, which is unfortunate, but the modern armourer can safely use mild steel for all but the best pieces.

Mild Steels

Cold-rolled steel with carbon contents ranging from 0.1 to 0.2 percent has approximately the same carbon content as medieval wrought iron, but it also includes other elements (chromium, manganese, vanadium, nickel, silicon, and tungsten). Modern steel also lacks slag. Medieval steels were probably considerably easier to forge-weld owing to the inclusion of slag, and it has been proposed that slag actually acted as a flux during the forge-welding process. Mild steels are also rolled in modern mills to achieve a uniform thickness, while medieval sheets were uneven in thickness, formed under the press of large hammers. Nor were slag and impurities evenly distributed since the metal was not melted as it is in modern induction-arc furnaces. All of these factors yield differences in color and performance that can highlight striking differences, a kind of "evenness" in modern reproductions absent from all but the best of the medieval originals.

Despite this, low-carbon steel is used in most reproduction projects because it is relatively inexpensive, can be obtained easily, and roughly approximates the wrought iron. Low-carbon steels come in both hot- and cold-rolled sheets. Hot-rolled steels are softer and easier to work, but they also have a coating of oxidation on the surface that can be difficult to remove.

In the production of any armour that is not to be raised, I prefer the cold-rolled metal

because it hardens well under the hammer, is relatively easy to work, and is far easier to clean up and polish. For raised helmets, hot-rolled is preferred because it starts off annealed, making the first few passes easier.

Medium/High-Carbon Steels

Metallography of steels used by medieval armourers of the late 14th and 15th centuries reveals hardnesses in the Vickers range of 300 to 500, with an average of 400. Dr. Alan William, archaeometallurgist at the Wallace Collection in London, has conducted important research revealing that steel in the 0.3 to 0.5 percent carbon range was used throughout a complete harness at least as early as 1380 (see sidebar on page 112).

Such hardnesses correspond to modern steels categorized by their carbon content running from 1030 to 1050. A steel with a number of 1030 contains 0.3 percent carbon, amongst other alloys, while one that is in the 1050 range has 0.5 percent carbon. Such specialty steels can be difficult to obtain, since aluminum and stainless steels have eclipsed most uses for carbon sheet. I have found a few sources for it, but usually it ships in narrow strips. If it can be procured, I highly recommend it both for reproduction and reenactor use since it can be made thinner and hardens nicely.

Stainless Steels

The so-called stainless steels are corrosion-resistant alloys with high manganese or chromium that resist rusting. Stainless steel comes in many grades, each one with a different and precisely controlled amount of alloys evenly distributed throughout. The result, when polished, is a very "white" metal that I find a bit too modern in feel for medieval armour reproductions. It is also much harder than even most medium-carbon steels, so it is very destructive to such workshop tools as hammers, stakes, and metal punches. That said, because the metal is very strong (though brittle), and because it resists weather and corrosion, some reenactors request stainless steels to be used in their harnesses.

Stainless is very low maintenance, it is true, but there is a drawback When it finally does scratch, the mark seems very obvious. Also, the holes around joint articulations and other areas tend to work-harden and produce cracks far sooner than comparable mild- or medium-carbon steel, because the alloying metals cause it to be far more brittle. Stainless steel barstock, however, is excellent for use in basket hilt defenses and helmet grilles, just as a matter of practicality.

THE MEDIEVAL METAL "LATTEN"—BRASS AND BRONZE

Throughout the Middle Ages, any copper alloy seems to have been referred to as "latten," though sometimes the more specific terms bronze or brass were used. Latten refers to any alloy of copper. Bronze is created from a copper-tin alloy (with trace metals), while brass is primarily copper with zinc and other trace elements.

Bronze as a material for armour dates back at least to Ancient Greece, where elaborate plate defenses were hand-raised to form the brilliant Corinthian-style helmets, muscled cuirasses, and greaves. Roman helmets were created using more mechanization, and bronze seems to have been largely replaced by iron by the 2nd century.

As an adornment, however, latten was popular throughout the 14th century. Armour was sometimes edged with stamped or engraved decoration in bronze or brass (fig. 23.3). It is possible that some elements of armour such as poleyns, gauntlet pieces, and even helmets were occasionally hammered from bronze or brass, but iron was largely favored because of its demonstrated toughness.

Borders and coronets were also sometimes cast and put into place. The Charles V armour in the Chartes Museum, the gauntlets in the Bargello Collection, and the effigy of the Black Prince all show cast elements. Some of these were latten while others were cast from silver or possibly even gold.

The modern armourer can obtain sheet brass with ease. Bronze is a bit trickier, but

Early Armour Metallurgy

Alan Williams[2]

A great deal of early armour is made simply of bloomery iron -that is, a mixture of iron with a small amount of carbon (usually less than 0.3 percent) and slag from the extraction process. Microscopic examination shows the iron appearing as light-colored grains with irregular boundaries, called "ferrite"; the carbon present appears in air-cooled steels as dark areas of pearlite (a mixture of iron and iron carbide). Quenched steels may be much harder because of the formation of a different crystalline material with a characteristic acicular appearance, called "martensite." Extraction slag (and if unskillfully turned from a billet into a plate, some smithing slag as well) appears as nonmetallic inclusions elongated in the direction of forging.

It is probable that only relatively small pieces of iron plate (up to about 0.5 kg in weight) were available before the mid 14^{th} century, when pieces large enough to make a one-piece breastplate appeared and then only in the technologically advanced areas such as Lombardy, which became the center for making armour of quality in Europe. Not only were larger pieces of plate available (perhaps 10 kg needed to make a breastplate, allowing for wastage), but their carbon content was more controllable. Steel rather than iron armour became a common (over 60 percent) product of Milanese armourers in the 15^{th} century, and the more ambitious attempted to harden the steel by some form of quenching.

Their German counterparts lagged well behind them; steel does not seem to have become common before the last quarter of the 15^{th} century in South German armour.

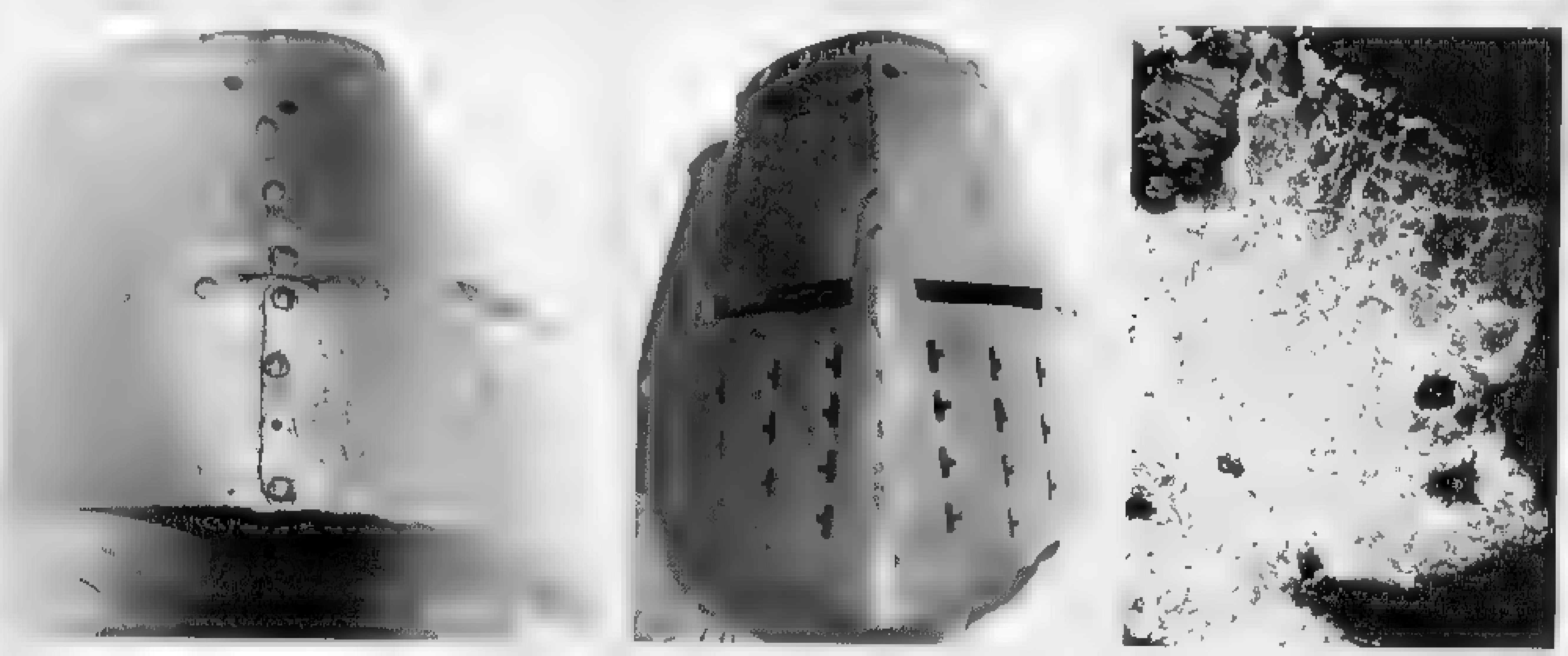


Figure 8 2. The great helm found at Bolzano/Bozen, now in the National Museum of Castel Sant Angelo (inventory number 869), late 13^{th}/early 14^{th} century It is made of four plates (and a crown plate) riveted together The front lower plate has a very heterogeneous microstructure of ferrite, sharply varying amounts of pearlite some small slag inclusions, and some large areas of corrosion The average microhardness was found to be 233 kg/mm² on the Vickers Pyramid Hardness scale (microstructure photo at 100x magnification)

Figure 8.3. A great deal of armour, generally of modest quality, has been excavated from mass graves dug for the battlefield of Wisby (1361) on the island of Gotland. The armour is mostly mail or lamellar in form and may well have been much older than the battle. The specimen shown here (90x magnification) is the cross-section of a severely corroded brigandine plate from grave 17530/DZ884. Approximate dimensions 9 x 2.5 cm. Within an outer envelope of iron oxide, about three-quarters of the original metal has survived. The microstructure consists of ferrite and slag only. It is simply a wrought iron (the dark area at one edge is due to staining of the ferrite during sample preparation; it is not pearlite). The hardness is estimated at 100 VPH.

Figure 8.4. A bascinet skull in the Poldi-Pezzuoli Museum in Milan (inventory number 2599) that was made c. 1330–1340 is the earliest successful hardened armour that I have yet examined. The cross-section at 600x magnification is uniform; it has not been case-carburized. The microstructure consists of a mixture of ferrite, martensite, and areas of iron carbide. Such a mixture is not generally found in the microstructures of modern steels. It suggests that this steel may have been raised to the upper critical temperature (bright red heat) and then—instead of being plunged immediately into cold water, with attendant risks of embrittlement, cracking, or warping—it was allowed to cool at a slightly slower rate so that an all-martensite structure was not produced, but ferrite was formed as well. A moderate increase in hardness, to about 350 VPH, would be an acceptable alternative to full quenching (to perhaps 600 VPH).

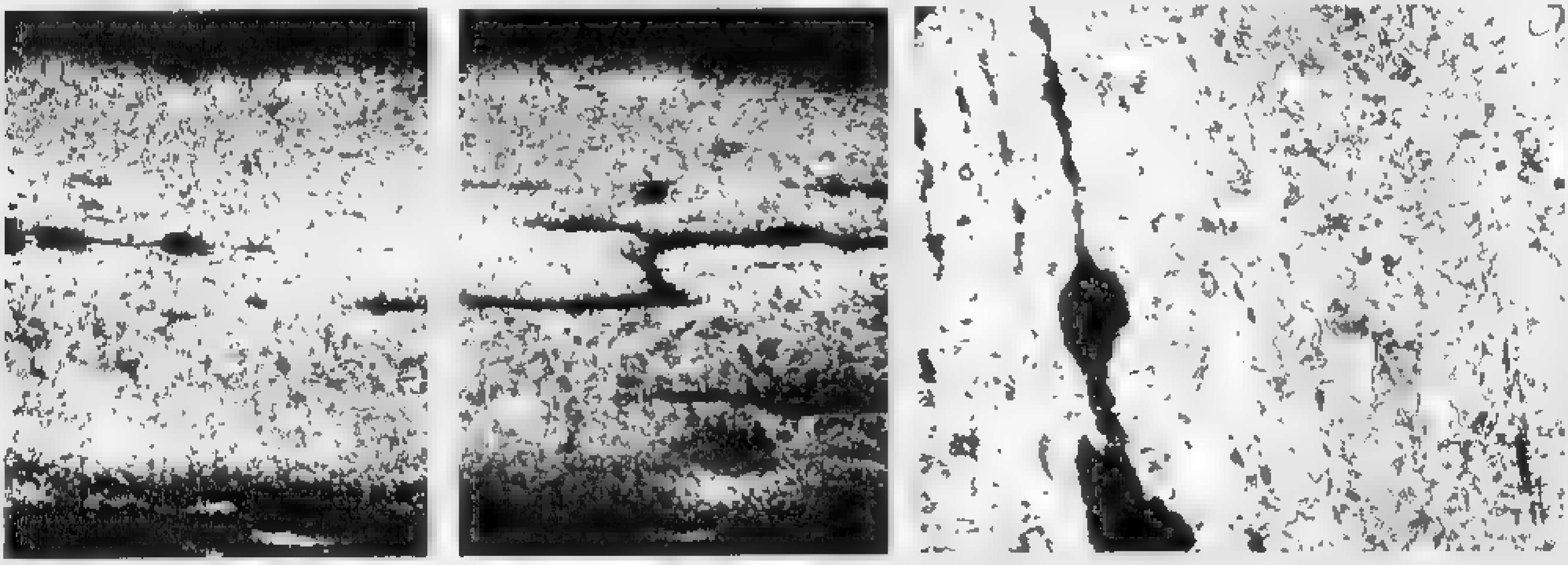


Figure 8.5. A pair of gauntlets in the Wallace Collection, London (inventory numbers A251–A252) of "hourglass" form and decorated with brass edging closely resemble a pair of gauntlets in Churburg (Mann-Trapp catalog number 13) and are thought to have been made in Milan c. 1360–1370. This was examined on the lower rim of the cuff; a large corrosion crack has opened up within the cross section. The microstructure (seen at 90x magnification in the photo) is that of a banded steel of around 0.4 percent carbon. Such banded steel is not uncommon in medieval artifacts and suggests that the process of turning a heterogeneous lump or "bloom" into plate involved folding and forging in an attempt to homogenize the steel. No attempt has been made to harden the steel by quenching. Evidently the hardness (about 250 VPH) was thought to be acceptable and the risks of quenching not worth any possible improvement. (See also fig. 33.1.)

Figure 8.6. A barbuta of the late 14th century now in the Royal Scottish Museum, Edinburgh (inventory number 1905.493). This was examined on the lower rim of the skull. The microstructure of this cross-section (at 80x magnification) contains a mixture of ferrite and pearlite with a carbon content of around 0.3 percent and hardness of 180 VPH. There are a few irregular slag inclusions.

some supply houses do stock it in sheet form. I generally recommend 16 or even 14 gauge for edging; otherwise the trim is too thin and will crumple under the stress of combat.

ANNEALING AND HARDENING

Ferrous metals—those containing iron and carbon—can be hardened and softened (annealed) using heat. As mentioned above, case-carburizing and other modern techniques can be used to reinforce and increase the carbon content of low-carbon steels, but this is a process that is largely out of the reach of most armourers and their clients. For the most part, reenactors and collectors are pleased to have pieces that are hardened through the hammer to provide a measure of rigidity.

Hammer-hardening involves hammering over the whole surface of the piece with a smooth-faced hammer, planishing the surface and compressing the metal crystals into uneven patterns that create a resistance to deformation. Whenever possible, this should be done as a final treatment to the metal even though it will not be evident in the final piece—it will make your work stand up longer, plus it will make finishing much easier since you will begin grinding on an evenly hammered surface.

When a good deal of hammering is required—as when raising a helmet from a single sheet—the metal will harden and become increasingly difficult to work. It can be softened by heating it to a red hot temperature and allowing it to cool. Heating and quenching in water, oil, or urine can also be used to harden steels with a higher carbon content, but unless the heat is carefully controlled, the results will be uneven. A kiln is recommended if this work is to be done with any degree of frequency.

Nonferrous metals—brass, bronze, aluminum, and the like—react in the opposite way. For a bronze helmet you would heat the metal to an even red temperature and allow it to cool slowly (preferably in an oven over a period of several hours) to harden it. To soften

Date	Harness Weight	Components
9th–13th century Hauberk	35 lbs	**Wallace Collection hauberk:** 20 lbs. (from 15th century examples), casque w/nasal (from 15th century sallet), probable aketon.
14th century Churburg #13	46 lbs.	**Churburg #13:** bascinet, visor & aventail, 11.75 lbs., segmented breastplate 5.83 lbs., arm harnesses 5.19 lbs., gauntlets 2.07 lbs., hauberk #2 from a slightly later period 20.72 lbs.
15th century (1470) Italian Milanese	51 lbs.	**Wallace Collection composite armour #B1:** armet a rondel, 7.48 lbs., left grandguard .66 lbs., cuirass 16.5 lbs., pauldrons and guards, 8.82 lbs., right arm 2.38 lbs., left arm & grandguard 2.99 lbs., cuisses 7.17 lbs., greaves 3.74 lbs.
15th century (1480) German Gothic c. 1480	57 lbs.	**Wallace Collection #A21:** helmet 8.90 lbs., gorget 2.96 lbs., breastplate 6.40 lbs., backplate & guard-reign 7.5 lbs., taces 6.5 lbs., pauldrons 4.40 lbs., arms 6.84 lbs., gauntlets 1.84 lbs., cuisses 3.2 lbs., greaves & sabatons 9.35 lbs.

it (or to soften brass), you can heat it to a cherry color and then drop it into water, where it will instantly soften.

WEIGHTS OF MEDIEVAL ARMOURS

The novice student of armour will be surprised to find how light swords and medieval armours actually were. These swords did not weigh 10 pounds—they averaged 2 1/2. A sword was a tool whose extended use was required to survive the bloody encounters of the medieval battlefield, and with a narrow edge, 2 1/2 pounds plus the mass of the horse was usually enough to do the job. Armour also weighed far less than is supposed, with full harnesses ranging from 35 pounds in the 11^{th} century to roughly 55 pounds during the heyday of armour in the 15^{th} century.

On page 114 is a comparison chart of full harnesses preserved in the Wallace and Churburg collections, plus the fine Italian armours studied by Boccia in his survey of the armour of Lombardy. The harnesses were chosen for their high quality and representation of different styles. Other examples would vary by approximately ±25 percent.

Just as a comparison, modern American infantrymen wear approximately 55 pounds in gear. At these weights, a man can easily train to move quickly and with great nimbleness providing that the armour is well crafted.

SELECTING METALS FOR ARMOUR WORN BY TOURNAMENT COMBATANTS

When selecting metals for reproduction or collection purposes, whenever possible the armourer should strive for material that comes closest to matching the historical type for his project. Arming the tournament combatant is as challenging as making an absolutely authentic reproduction. The armourer must analyze the style of fighting the armour will be used for, the motions required by the combatant, and the desired effect

In most tournament reenactments, repeated impact by either heavy or sharp weapons has the potential to cause damage to the armour and injury to the combatant. A good armourer will, while not guaranteeing complete safety, strive to provide as much as possible.

Mobility is a crucial factor for combatants. Good armour, whether medieval or modern, serves the form of combat it is intended for by allowing as full a range of mobility as possible while simultaneously maximizing the defense. At the same time, some combatants want to present as authentic an image on the field as possible while also being competitive within the lists.

Unfortunately for the martial art, most armourers are as yet unable to work with medium-carbon steels to gain the exquisite balance between hardness and toughness that characterized the finer medieval work. As such, the armour produced is generally a full gauge or even two heavier than were the medieval originals. This reduces the appeal of full arm and leg harnesses and puts the combatants who adopt it at a competitive disadvantage. If more armourers were to master working in the medium-carbon steels, more combatants would likely select such armour as a clearly superior defense for tournament combat.

The armourer must remember that mass is an important part of the defense when heavy weapons—like the rattan used in SCA combat—are faced. A plate's ability to resist impact relates both to its hardness and its mass.

In the table above, ranges are given for the major classes of armour worn by tournament combatants. The armourer must decide whether or not the piece will be heavily used, whether the impacts received are going to overwhelm a lighter gauge material, and the size and build of the combatant in question. For any of the listings below, for properly heat-treated medium-carbon steels in the 1030–1050 range, one or two gauges lighter can usually be employed.

Helmets

Twelve gauge is harder to work than 14, but for any helmet where the skull is likely to be

Armour Thickness Quick Reference Chart

Defense	Reenactor All given for mild steel *		Authentic Steel quality unspecified	
	Thickness	Weight	Example	Weight
Helmet				
Skull	12–14g.	5.5 lbs.[3]	Wallace Bascinet[6]	4.44 lbs.
Brow Reinforce	14g.		Hundskul visor	1.81 lbs.
Visor (sidemount)	12–14g.	4.0 lbs.[4]		
(centermount)		1.2 lbs.[5]	It. Salet c. 1480[7]	7.07 lbs.
Gorget (brigandine)	16–18g.	2.2 lbs.[8]	c. 1620[9]	2.12 lbs.
Cuirass				
Brigandine plates	7.5 lbs.[10]		Milanese c. 1410[13]	5.76 lbs.
Breastplate	16–18g.		Milanese c. 1475[14]	3.98 lbs.
Backplate	14–16g.		It. faulds c. 1450[15]	3.47 lbs.
Faulds (front)	16–20g.		It. fauld c. 1480[16]	1.43 lb.
Faulds (back)	14g.		Milanese c. 1450[17]	.85 lb.
Taces	16–18g.			
Wisby Brigandine	14–16g.			
Churburg #13 breastplate	18g.	7.1 lbs.[11]		
	14–16g.	4.5 lbs.[12]		
Cuisses		5.0 lbs.[18]		
Poleyns	14g.		Cuisse, 15^{th} c.[19]	2.73 lbs.
Lames	14–16g.			
Demi-Greaves	16–18g.			
Full greave	18–20g.		It. greave, 15^{th} c.[20]	2.33 lbs.
Sabatons	18–22g.		Single sabaton[21]	1.29 lb.
Shoulder Defenses	14^{th} c. spaulder	1.2 lb.[22]	16^{th} c. spaulder[23]	1.1 lb.
Epaule, Cop	16–18g.			
Lames	16–18g.		It. Pauldron[24]	3.52 lbs.
Arm Harnesses		2.8 lbs.[25]	14^{th} c. arm[27]	2.61 lbs.
Couter	14–16g.	.5 lb.[26]	Couter, 15^{th} c.[28]	.44 lb.
Lames	16–18g.			
Vambrace + Rerebrace	16–18g.		Vambrace, 15^{th} c.[29]	1.38 lb.
Gauntlets			14^{th} c. hourglass[32]	.96 lb.
Mitten finger defenses	14–16g.	2.0 lbs.[30]	It. Mitten, c. 1450[33]	.85 lb.
Finger gauntlet defenses	14–16g.	2.0 lbs.[31]	Gothic gauntlet[34]	.69 lb.

* Most armour made for living history and behourd-style combat is made from cold-rolled mild steels. If the armourer decides to use a high-carbon (spring) or stainless steel for the pieces, or the pieces are substantially reinforced by layering, embossing, fluting, etc., then one or two even gauges less material can be used. Helmets should not be made from less than 14 gauge steel if they are to be used in combat because mass is an important part of its defensive qualities.

dished or raised significantly, use 12 gauge if at all possible. Within the SCA, I have seen 14 gauge helmets dent in the first few encounters; plus they do not provide quite as much mass to defend the head, so thicker padding is required to make up the difference. For brow reinforces, 14 is the only gauge I recommend since this zone is commonly struck. Visors should be 12 or 14 gauge depending upon how often they will be used. William Radford, the preeminent British armourer, has offered that his raised helmet projects begin with 10 gauge material, suggesting that more material can be removed and, worked hot, the effort to manipulate it is not substantially increased.

Gorgets

The throat is sometimes defended only by a kind of collar of brigandine or naked plates. Most tournament groups require this defense, although medieval counterparts are very difficult to locate. A thickness of 16 or 18 gauge is usually sufficient since the neck is not often struck directly. Mail aventails and mantles are often used for this purpose; they work better and are appropriate on armours of both the 14th and 15th centuries.

Cuirasses

Brigandine defenses are the most common form of body defense, and luckily the leather sheathing provides a measure of shock absorption. Sixteen or 18 gauge plates are more than sufficient for this. The breastplate is often struck, however, so 14 gauge is commonly used.

During the "white armour" period of the 15th century, the benefits of heat-treated spring steels became readily apparent. It appears that Milanese cuirasses, for example, weighed in at less than 22 pounds, while several modern examples I have examined have come in closer to 30 pounds.

In a single-piece breastplate, common throughout the 14th century, 14 gauge is a good choice because it can be moved around quickly and then ground. Very large or very small combatants might find the weight of a 14 gauge breastplate difficult to handle. In these cases, 16 gauge might be considered, but it will likely dent quickly if no heat-treating is done. Backplates are struck far less frequently, so they can actually be quite thin—16 to 20 gauge suffices. Faulds, the horizontal hoops that encircle the waist, must be thick in the front and thin in the back for the same reasons; 14 and 16 gauge respectively are good choices. Taces are the extra hanging defenses added to 15th–16th century harnesses to bridge the gap between the fault and upper portion of the cuisse. Frontal faces should be heavy, although I sometimes use a 16 gauge tace on the right (since it is hit less frequently then the left) and a 14 gauge one on the left. Decorative faces on the back of the cuirass can easily be 18 gauge.

Leg Defenses

The cuisses need not be symmetrical in thickness, since they are punished unequally. The left should be no less than 14 gauge but the right can be thinner. Leather-covered cuisses can also be thinner, since the leather helps to stiffen them and damage is less apparent. The poleyn or knee defense should be heavy if it has been domed; 14 gauge is a fairly standard thickness. The upper lames should be as thick as the cuisse since they share the same target, though the lower lames can be a gauge lighter. Demi-greaves, the most common finish for reenactment leg harnesses, can also be light but not too light, since they sometimes take the whole weight of the combatant when kneeling. I recommend 16 gauge. Full greaves, though rarely creased for tournament reenactors because of their complexity, can be very thin; 18 or even 20 gauge. But remember: very thin greaves must still be heavily worked, heated, ground, sanded, and polished. Sometimes if the metal is too thin they will dent or malform quickly. Heat-treating is highly recommended to preserve finely wrought greaves.

Spring steel is very useful in the production of a leg harness, since the weight of the whole harness can be reduced by nearly a quarter and its durability improved significantly.

Sabatons

The defense for the foot need not be very heavy, 18 gauge being standard

Shoulder Defenses

For large shoulder defenses—pauldrons as opposed to the smaller spaulders—thickness of the steel is a concern, since a great deal of weight can be added quickly. However, if the defense is a small one (e.g., a spaulder or cop alone), heavier metal is recommended because there is little mass or reinforcement to keep the plate from bending. Sixteen gauge is a good choice. Lames can usually be of 18 gauge material since their overlapping nature provides added resistance to bending

Gauntlets

The "mitten" style gauntlets popular in Italian armours of the 15th century and in some international armours of the 16th century can be made from 14 gauge material throughout. They must sustain repeated impacts by pole weapons and swords directly, so the mass helps both to protect the delicate bones of the hand and prevent the small plates in the gauntlet from malforming The less popular finger style gauntlet plates can actually be thinner, though they should be made from spring steel or brass to preserve their shape. Normally these plates are embossed enough to keep them from twisting, though they provide little in the way of mass.

ENDNOTES

1 Theophilus recorded a rich variety of artistic techniques in his famous *On Divers Arts*, written c A D 1122.

2 Dr. Williams is the best-known authority on archeometallulgy in the arms and armour field today. His written works on the subject span 20 years and would prove too long to list here. He has provided the following list of resources for recommended further reading on this topic·

"The mass-production of armour plate and the blast furnace," *History of Technology Annual*, 16 (1994), pp. 98–138

"Fifteenth century armour from Churburg; a metallurgical study," Armi Antiche, 32 (1986). p. 3.

"Four helms of the 14th century compared," *Journal of the Arms & Armour Society*, 10 (1981), p. 80

3 Bascinet for béhourd-style combat by the author with grilled visor of 12 gauge mild steel

4 Side-mount bascinet visor for béhourd style combat by the author of 12 gauge mild steel

5 Center mount bascinet visor for béhourd-style combat by the author of 14 gauge spring steel.

6 Wallace Collection bascinet, c. 1400 (Mann, Vol 1, p. 93). The Churburg bascinet shows a similar relationship, the weight of the entire helmet and visor a grand total of 6.15 lbs.

7 Churburg Collection, Milanese sallet and visor, without bevor, late 15th century (Trapp, Vol. 1, p. 65) The associated bevor weighs 1 87 lbs Compare this with a German sallet from the same period—Wallace #A80—at 3.62 lbs. (Mann, p. 99).

8 Anachronistic brigandine gorges intended for béhourd-style tournament combat. 18 gauge plates throughout, 6 ounce leather

9 Wallace Collection gorget #234, c. 1620, made by Hieronymous Ringler of Augsburg, (Mann, Vol 1 p 170). Compare also with the Churburg gorget, c. 1500, on armour #69, weighing in at 2.42 lbs. (Trapp, Vol. 1, p. 105).

10 Covered cuirass, c. 1400, reproduction by the author, 16 gauge material throughout covered with thin leather and a substantial number of bronze rivets

11 Wisby #7 coat of plates built for this book from 18 gauge material and 8 ounce leather with straps and fittings but without épaules

12 Churburg #13 breastplate for béhourd-style combat in mild steel by the author, 14 gauge centerplate with latten borders of 16 gauge material 3/4 inch wide. All other plates of 18 gauge.

13 Churburg Collection breastplate #14 (Trapp, Vol. 1, p. 27), German, c. 1410. Compare this with a full Italian cuirass, c. 1450, also from the Churburg Collection (Trapp, Vol. 1, p. 59). Upper breast and back, 2.08 lbs.; lower placards and faulds, 3.36 lbs.

14 Churburg Collection, German composite harness #24 (Trapp, Vol. 1, p. 65)

15 De la Gratze Collection, Italian faulds, front and back, on #B2 (Boccia, *Lombarde*, p. 246)

16 De la Gratze Collection, Italian fauld, #B37 (Boccia *Lombarde*, p. 278). Back fauld, single piece

17 De la Gratze Collection, Italian tace on #B2 (Boccia *Lombarde*, p. 246–247). The left is heavier by 10 grams

18 Cuisse, poleyn, and two lames done in the 14th century style by the author, c. 1990. All in mild steel 14 gauge poleyn and cuisses, 16 gauge lames, 18 gauge demi-greaves, 1 inch 14 gauge border along the lower edge.

19 Churburg Collection, leg harness without poleyns, later 15th century (Trapp, Vol. 1, p. 86)

20 Churburg Collection, Italian greave on #21, c 1450 (Trapp, Vol. 1, p. 59), for a single lower leg. Compare this with the backplate of a single greave from Churburg, #55, 15th century, weighing 1.056 lbs (Trapp., Vol. 1, p. 87).

21 Churburg Collection #75, single sabaton, c. 1520, German (Trapp, Vol. 1, p. 117)
22 Spaulder made for this book in the late 14th century style from 18 gauge mild steel
23 De la Gratze Collection, late Italian spaulder #B26, single piece, c. 1500 (Boccia, *Lombarde*, p. 275)
24 De la Gratze Collection, Italian pauldron on #B2, c. 1450 (Boccia, *Lombarde*, p. 247). This is without the grandguard used to provide extra defense in some encounters
25 Churburg #13 style arm defense of mild steel, 14 gauge couters, 18 gauge hardened spring steel vambraces, rerebraces and lames, no latten border
26 Churburg #13 style couter by the author, without latten border from 14 gauge mild steel, intended for béhourd-style combat
27 Churburg Collection #13, c. 1390, a fully enclosed arm harness in the vambrace, open rerebrace, and articulating couter on two lames (Trapp, Vol. 1, p. 23)
28 Churburg Collection #46, 15th century Italian couter or elbow cop (Trapp, Vol. 1, p. 82).
29 Churburg Collection #48, left vambrace complete with wrap plate and hinges (Trapp, Vol. 1, p. 83)
30 Milanese mitten gauntlet reproduction by the author, c. 1460, from 14 gauge mild steel, fitted with a glove and finger tip plates
31 Hourglass gauntlet reproduction by the author, c. 1380, with thick (14 gauge) latten border intended to help reinforce the cuff for behourd-style combat.
32 Wallace Collection #252, classic hourglass-style gauntlets, without brass bracelet on wrist (Mann, pp. 176–177). The other gauntlet, which still possesses the bracelet, weighs 1.1 lbs. Note also that this gauntlet lacks the finger defenses, palm strap, and glove, which would probably bring the weight of the finished gauntlet to something like 1 1/2 lbs.
33 De la Gratze Collection, Italian mitten gauntlet on #B2 (Boccia, *Lombarde*, p. 247)
34 Churburg Collection #49, includes all finger plates intact (Trapp, Vol. 1, p. 85).

SECTION THREE

TECHNIQUES

Figure 9-1. To transform a flat sheet of gray steel into a finished piece of armour, a variety of steps are required: design, measurement, patterning, cutting and deburring, forming, fitting and articulating, finishing, assembly, strapping, and maintenance. This closeup of an armet a rondel was crafted for Karl Lieder by Aaron Toman and Wade Allen.

Chapter

Steps Required for All Pieces

During the course of their creation, all armour pieces go through roughly the same stages of construction, each of which will be covered in at least one chapter in this section. All pieces go through phases of measurement and design; cutting and deburring; forming, fitting, and articulating; grinding and polishing; assembly; strapping, and waxing and maintenance

MEASUREMENTS

It is handy to take detailed measurements for the intended wearer of the armour before work is begun It is convenient to have the patron physically present when the pieces are being fitted, but accurate measurements will enable the armourer to approximate the size of the patron.

RESEARCH AND DESIGN

Before any work is done, research and design should be conducted to obtain as much information as possible for the design decisions necessary. Study photographs, drawings, and conceptual notes are all valuable.

PATTERNING

With a design in mind, the necessary patterns can be derived and set down on paper. These can be as simple as the large circle used to raise a helmet in one piece to detailed lames needed for gauntlets or other limb defenses. Some changes in the initial pattern will doubtless be suggested as the work progresses, and these should be noted on the pattern itself—on its envelope or in the armourer's notebook—for future reference.

CUTTING AND DEBURRING

Once the patterns have been created, the piece is usually traced onto a sheet of steel with a permanent marker and cut using a shear or saw. Cutting leaves sharp edges and may be imprecise. Files and sanders are used to quickly deburr the edge so that the lines are smooth, presenting no nicks that can become tears and helping to protect the armourer from burrs and sharp edges.

FORMING

Without question the most intensive and important phase—and usually the longest—is when the piece is hammered into shape. Sometimes this is done cold and sometimes it's done hot. Basic forming is done through doming, raising, or flaring. Enhancements such as creases, rolled edges, flutes, and embossed edges will sometimes be added after sanding but are more usually done after rough forming is complete.

FITTING AND ARTICULATION

Connecting individual pieces together—either through engineered joints (called articulations) or joining them with rivets or welds—is the next step. Careful fitting and adjustments are necessary. Articulations are held in place with temporary bolts, which are removed for finishing.

GRINDING AND POLISHING

The final pieces are ground with a sander and polished on a buffing wheel. A very few pieces, usually of munitions quality, are left rough from the hammer. Polish helps the armour to resist rust and enable blows to glance from the surface. It is helpful to paint or tin the interior of the pieces to reduce damage that will be later caused by rust.

ENHANCEMENT

Some pieces are enhanced through the addition of brass borders, etching, engraving, or other decorative feature. This work is usually—but not always—done after polishing.

Enhancements should only be added where they are appropriate to the period. There is a temptation for the intermediate armourer to add enhancements in an effort to cover less than perfect craftsmanship, but this urge should be resisted. Appropriate enhancements must accompany quality workmanship only. Otherwise, this same effort would be better spent refining the piece itself.

ASSEMBLY AND STRAPPING

The polished and fitted pieces are then assembled using rivets and interior leathers. Leather straps and buckles are also affixed at this stage, and the piece is ready to wear. Helmets are then padded with sewn linings or protective foam.

CLEANING, WAXING, AND MAINTENANCE

A thin coat of floor or microcrystalline wax is applied to the armour's surface. If it is to be a display piece, then a good coat of microcrystalline wax will go a long way to preserving the finish without rust. Armour used for combat will need hammerwork and joint repair and should be stored in wax-impregnated bags to help it survive the dangers of frost and transport.

Chapter 10

Training the Hammer and the Eye

Technologies have improved the process somewhat for the modern armourer, but the basic steps have remained identical for more than 700 years. The pieces are still cut from sheet stock with manual shears, most of the forming is done with a hammer over various stakes, polishing is still done on a wheel, and heat is still required for annealing, hot working, and joinery.

Machining technology has yielded surprisingly little to change the armourer's technique, except that the power sources have changed, the materials available are more homogenous and consistent, and thankfully, dust-collection procedures have been vastly improved. Some of the key tools used by most armourers are mass-produced, so at least shears, punches, and hammers can be acquired by anyone.

Although some improvements have lowered the barrier necessary for novice and intermediate armourers to get started in this craft, caution should be exercised, for every modern technique used can draw the final product that much further from the medieval original. The modern armourer should strive to think about how his medieval counterpart would have solved the same problem he is faced with and work out how it would have been done originally.

Opposite page
Figure 10.1. Skillful reproductions require training the physical skills required to manipulate and engineer the metal combined with an increasingly critical eye refined through exposure to as many authentic examples as possible. This sallet, crafted by Theodore Monnich, displays such detail as the gilded wooden crest that distinguishes an extraordinary effort from a mediocre one.

As you begin to grow as an armourer, you need to develop two different aspects of your skill. By the constant use of and practice with the tools of the trade—especially the hammer—you will learn physical techniques necessary to create the pieces you envision. But of equal importance is the refinement you must develop in calibrating your eye. You must learn to critically examine historical examples and your own work to discern fine differences, to see beyond the obvious, and to refine your work over time. You must learn as much as possible about the period in which you desire to work because the armourer who wishes to build his skill must be able to identify elements of style in each given school of armour and incorporate them into his own pieces.

Figure 10.2 Modern armourers strive to calibrate their eye and improve their technique to the point where they can create copies of extant pieces that are as accurate as possible. More often, they are called upon to create new pieces in an appropriate style, building an original example that "could have been" from a given period. The above reconstruction by Wade Allen shows the crispness possible with experience and careful execution.

Of the two, refining the hammer is by far the easier task. The skills required to produce a fine reproduction are mostly the ability to be consistent in hammersmithing, to have enough patience to work the metal evenly, and to have enough knowledge of the tools that enhancements to the basic pieces of plate are done cleanly. I sum these components up as "learning the hammer," though in practice all the basic techniques need to be mastered.

The best way to build technical skill is through practice on simple projects. Striving to make the hammer marks regular on even the simplest of pieces will go a long way to refining the armourer's overall quality. Diligence and a demand for continued excellence is what will drive steadily improving technique. The armourer who wishes to grow must not rush toward completion if it means sacrificing the quality of a piece, because the end product always stands as testimony to the patience and skill expended in producing it.

There is a tendency for armourers to gloss over the central techniques—regular hammer strokes, bouging, planishing, careful sanding and polishing—in favor of fancy enhancements. I call this tendency toward the complex "glitz disease," and it should be avoided at all costs.

To create a piece of great beauty does not require complicated, advanced technique. Simple technique well-executed does more for an armourer's development and for the overall value of the piece than does one with rushed foundational techniques liberally covered with fluting, etching, embossing, or brass adornment. In a well-made piece, the simple lines will come through in a statement of elegant simplicity. Until the basic techniques are well in hand, the piece will be improved only as a veneer if improved with a facing; it has no artistic depth, no reality, and far less value as a work of fine craftsmanship, much less art.

The novice and intermediate armourer should therefore work toward perfection in the

basic skills as presented in this book and as learned from advanced armourers. Most armourers who strive toward the pinnacle of the craft fall short because of this simple failing. The time is well spent and development is far quicker if you build the foundation skills first.

DEVELOPING THE EYE

Development of the hammer is, unfortunately, often stalled by lack of growth in the ability to see the line and critique one's own work. Many of the same armourers who strive toward excellence never advance past mediocrity because they cannot see the differences between their own work and the medieval originals.

The most important component of training the eye is the study of remaining examples from the period that interests the armourer most. While it is difficult in the United States to see armour firsthand, especially examples dated prior to the 16th century, there are many books available that will start the process. An armourer who strives to improve his eye should study in great detail every known example of his favored style. Even after years of glancing through my library, I still find things, even in my favorite pieces, that I had not seen before.

Additionally, the armourer should at least be passingly familiar with art and culture from the same period. Local classes at community colleges or universities are invaluable for this, helping to introduce the armourer to artistic elements of style common to all forms of art of the period while simultaneously exploring the artistic and craft culture in which medieval armourers moved.

An armourer should strive to develop at least a rudimentary skill at drawing because it yields a rich refinement in the perception of subtle differences in line. This skill is absolutely indispensable. Before starting a project, you can test how well you know the lines required by a piece by attempting to draw it out, preferably full size. You might be surprised at how poorly you really know what you are about to try to build.

The best way to get a feel for the real pieces is to handle them firsthand. Museums are generally helpful to those interested enough in such an esoteric art. Write them in advance, offering an explanation of specific pieces in their collections and perhaps photographs of your own work. If you present yourself with grace and sincerity, there is every chance they will let you behind the scenes to handle authentic medieval examples. Bring cotton gloves!

Once there, handle the pieces with great care, yet allow your thinly gloved hands to wander all over the surface, much like you would with fine sculpture. Feel the differences; drink in the essence of the piece. You are training both your hands and your eyes in so doing, plus you will find that the magic of the piece will likely rub off on you, exciting you such that you can't wait to return to the workshop and build the greatest piece ever made.

Lastly, you must do one last, difficult thing to progress. Even before your work is complete, you should look at it critically to see the differences between it and the example or style you are working against. Notice the small differences, even if you do not possess the technical skill to correct them—yet. Just seeing them will reduce your variance on the next attempt. This last skill requires a bit of humility, a noble virtue that actually strengthens rather than weakens because the man who is humble possesses a potent weapon against the most dangerous of vices—pride. And it is often pride and ego that stand in the craftsman's way, blinding him to the mediocre value of his work

Figure 11.1. In order to create the most accurate, functional example of medieval armour—whether a copy of an existing piece or an original in an appropriate style—research is critical to success. Not only should the armourer pour over every available written and photographic source, but whenever possible, the authentic examples should be examined firsthand. The education thus received is irreplaceable and often makes the difference between an intermediate and a budding master armourer. Peter Fuller, the craftsman responsible for the Vendel helmet at left, has been a curator for the Glenbow Museum in Canada and has an excellent sense of context that is difficult to obtain without firsthand experience.

Chapter

Conducting Research

No technique is as important as research. Background research is necessary to calibrate the eye and to enable the armourer to make better decisions during the project's execution. Project research, conducted just before and during the creation of a piece, insures that the details are right and that the lines have a chance at matching the real examples rather than being just hinted impressions.

BACKGROUND RESEARCH

Most of the background research for medieval armour must be conducted with the sadly limited material available. Scholars and enthusiastic amateurs in the 19th and early 20th centuries produced a few fine, though hard to find, references. During the 1980s and 1990s, more high-quality books were produced, but these are prohibitively expensive, and few libraries have them. Most of them are in the hands of collectors, museums, or the better armourers.

Books

Survey books have recently been produced that are of great value to the armourer. The most available of these, *Arms and Armour of the Medieval Knight*, was

published in 1986 and has enjoyed several reprints. It is accurate, features some of the finest pieces extant, is easy to read, and is very inexpensively obtained. I recommend two copies—one for the shelf and one for the shop.

Other scholarly books should also be obtained—at least from the library if not purchased, and probably through interlibrary loan—and read. At the top of this list must be Claude Blair's *European Armour* (Mr. Blair is the modern father of armour research), followed by Paul Martin's *Armour and Weapons*, and, eventually, Sir Guy Laking's *Arms and Armour through Seven Centuries*. Its five weighty volumes are thick with text and are difficult to obtain, even through interlibrary loan.

Specialty books have been produced for a number of periods. Working in the 1980s, Lionello Boccia wrote three volumes on Italian armour of the 15th and 16th centuries. Sadly there is nothing comparable for German armour of the same period, but surely something will be provided eventually.

Bengt Thordeman, writing on the Battle of Wisby (1361) excavation, found a rich collection of armour from the middle of the 14th century. This find now represents a unique survey of armour of the transition, including detailed construction details for coats of plate, gauntlets, and other brigandine armours. Unfortunately, there are few other works to equal it for armour of other periods.

Museum collections sometimes publish works on their collections, but sadly these seem to quickly go out of print. The Royal Armouries, late of the Tower but now in Leeds, Great Britain, has been surveyed only once in recent history, by A.R. Dufty in 1968. The

Figure 11.2 While written and photographic sources cannot take the place of actual handling of the medieval originals, much research can be done even without an excursion to a museum. All armourers should have the cornerstone books listed in this chapter, and the occasional article makes many periodicals valuable as well.

Wallace Collection in London has a respectable collection and some very rare pieces from the 15th century. The Metropolitan Museum of Art in New York has an astounding collection recently moved into a new wing, but no systematic catalogue exists. The Real Armeria (Madrid), the Bargello and Stibbert Collections (Florence), the Waffensamlung and the Gratz (Vienna), Musée de l'Armée (Paris), the Philadelphia Museum of Art, the Higgins Armoury (Worchester, Massachusetts), the Cleveland Museum of Art, and the Art Institute of Chicago all have put out limited publications that might be useful. The armourer should become familiar with these sources since there are so few of them.

Books intended for a younger audience are rich in pictures but are often full of mistakes as well, so approach the text and the dates with caution. Yet such books are frequently produced and often lavishly illustrated, so they can yield interesting new photographs for study.

Periodicals

Added to the cornerstone books are a few periodicals, most notably the *Journal of the Arms and Armour Society*, *Archeologia*, and *Men at Arms*, that feature articles of interest to the armourer. The *Journal*, produced quarterly, features many articles on firearms, but occasionally a piece on medieval armour will be included. These articles are usually narrowly focused, but this is where you will find cutting-edge research in the field if you care to look for it.

Annuals and bulletins from the world's museums can also be useful. The Royal Armouries now produces an annual that contains a collection of papers, some of which represent the current state of research in various aspects of armour. The Metropolitan Museum of Art's bulletin sometimes features an article on newly acquired armour. The Higgen's Armoury puts out *Ventail*, a quarterly newsletter built mostly around the museum's rapidly expanding public education program.

Chronique: The Journal of Chivalry and other specialty journals such as the now defunct *Lorica* and *The Hammer* began with tournament reenactments and the SCA. Although only *Chronique* is still in circulation as of the publication of this book, all three contain both survey and how-to articles aimed at reenactors. *The Hammer* was a prolific journal for a number of years, and although the articles were of an uneven quality, this fine publication served hundreds of armourers and helped to start the current renaissance of interest in the field. It is well worth the effort to find back issues of these journals, but they are not easy to locate.

Internet

During the 1990s, quite a few web sites sprung into existence on the topic of arms and armour. The material available on these sites should be treated as suspect; some are reasonably accurate but most are fraught with errors. Many of them feature photographs of authentic pieces, however, and if you know what you are looking at, you might find new pieces from private collections you have not seen before. Also, some of these sites feature bulletin boards or discussion groups where armourers can discuss questions and problems. But again, buyer beware—many consider themselves "experts" and might put their opinions forward aggressively. This is a component of Internet culture that you must evaluate carefully before accepting anything at face value. If you listen more than you talk, you can learn a great deal.

Museums

Nothing matches a trip to a museum, especially if you can handle authentic pieces. There is absolutely nothing that can replace a hands-on examination of a piece the armourer wishes to know better.

When dealing with museum curators, seek out the specific arms and armour specialist. Write to the person in advance, being professional and respectful. Indicate your interest and inquire about the possibility of studying one or more pieces. Keep your queries limited to a couple of pieces per trip, remaining aware that museums are generally underfunded and thus the curatorial staff is often pressed for time, so don't waste it.

When you arrive, bring camera equipment, a sketchbook, measuring devices, and most importantly, cotton gloves. If you are fortunate enough to handle real pieces, treat them as if they were made of glass. They are exceedingly expensive and valuable.

Check in advance to see if the museum will allow photographs. Be aware that most museums guard their copyrights closely, so photographs you take of their pieces cannot be published without their written permission. In some cases a museum will disapprove of copies of its pieces, since this also infringes on their ownership rights. In most cases, however, they do not seem to be bothered by armourers making reproductions of their pieces, provided that it is done on a relatively small scale and thus represents no financial loss.

Collectors

In some of the major metropolitan areas of the United States and in the castles of Europe, you will find a few private collectors. These collectors might well have good quality pieces from the 16th and 17th centuries, and a rich few might have a piece or two from the 15th. If you can find them, they are valuable contacts not only for their enthusiasm and collections but as potential patrons of your work, if you manage to improve your skills to the point where you can create passable reproductions.

Auction Catalogs

Collectors purchase their armour from auction houses or specialty antique dealers. Such auctions produce color catalogues before each sale, prospectuses that usually feature high-quality photographs of the better pieces and descriptions of all lots offered on the date in question. Sotheby's and Christie's are the two largest auction houses, the best auctions being held in London and Berlin, although New York also sees a fairly good supply of 17th century armour. On the American West Coast, Butterfield and Butterfield is the only real source of quality.

Auction catalogues are expensive, but if you can find them at a reasonable price or secondhand they are worth looking at. Who knows—perhaps you'll even purchase your own authentic pieces when you know what you are doing!

Monumental Brasses and Funerary Effigies

Sprinkled throughout the general arms and armour literature are references to monumental brasses and funerary effigies. Essentially elaborate medieval tombstones, these sometimes highly detailed representations of the deceased usually show the knight in armour.

For the 14th century, these precious references are often the only period sources available to the arms and armour student, but they are not without their problems. Like all representations, there is a problem in determining the accuracy of the depiction. Funerary brasses were made by craftsmen who probably adhered to stylistic preferences of the time. Some representations appear to be so highly detailed that their accuracy is in doubt.

Traditional dating on effigies generally give the date of the knight's death, which often is far later than his likely date of military service. Is the equipment shown the knight's own and, if so, how obsolete is it?

Bearing these questions in mind, and given the scarcity of surviving examples from the transitional period in particular, funerary brasses and monumental effigies remain the most valuable source for stylistic variation throughout the 14th century. Because of an associated interest in heraldry and genealogy, there are many books showing page after page of armoured figures in effigy form from the 14th and 15th centuries, valuable resources for any student of arms and armour.

Iconographical References

Artistic renditions of a soldier's equipment can also provide limited clues concerning the development of armour. Unfortunately, most art surviving from the 14th and 15th centuries is ecclesiastical rather than secular, so military equipment is a bit peripheral to the subjects rendered. Illuminated manuscripts in particular bear this problem, since the monks involved

were likely not as familiar with the equipment as were the great 15th century artists.

Yet some of these references were secular in nature, including illuminated copies of Froissart's *Chronicles*, the *Grandes Chroniques de France*, or any of the many romances from the time. These fine books were in demand by the wealthier members of the nobility, their flowery themes richly embroidered with equally colorful idealizations of knightly feats of arms. To my mind they are fine references to show general trends but should be approached with scepticism where a specific detail is concerned.

Some of the outstanding artists of the 15th and 16th centuries—da Vinci, Uccello, and Durer among them—have left exceptionally fine portrayals of armour from their respective periods. Uccello's *Rout of San Romano* deserves special mention since it shows a host of details for Milanese armour of the mid 15th century as well as combatants executing fighting skills. Some caution must still be extended, but their nearly photographic detail recommends them as valuable references for pieces that no longer exist.

A Note on Composite Armours and Forgeries

Now that you know where to find all of these rich sources, a word of warning: many of the "full harnesses" you find today in books

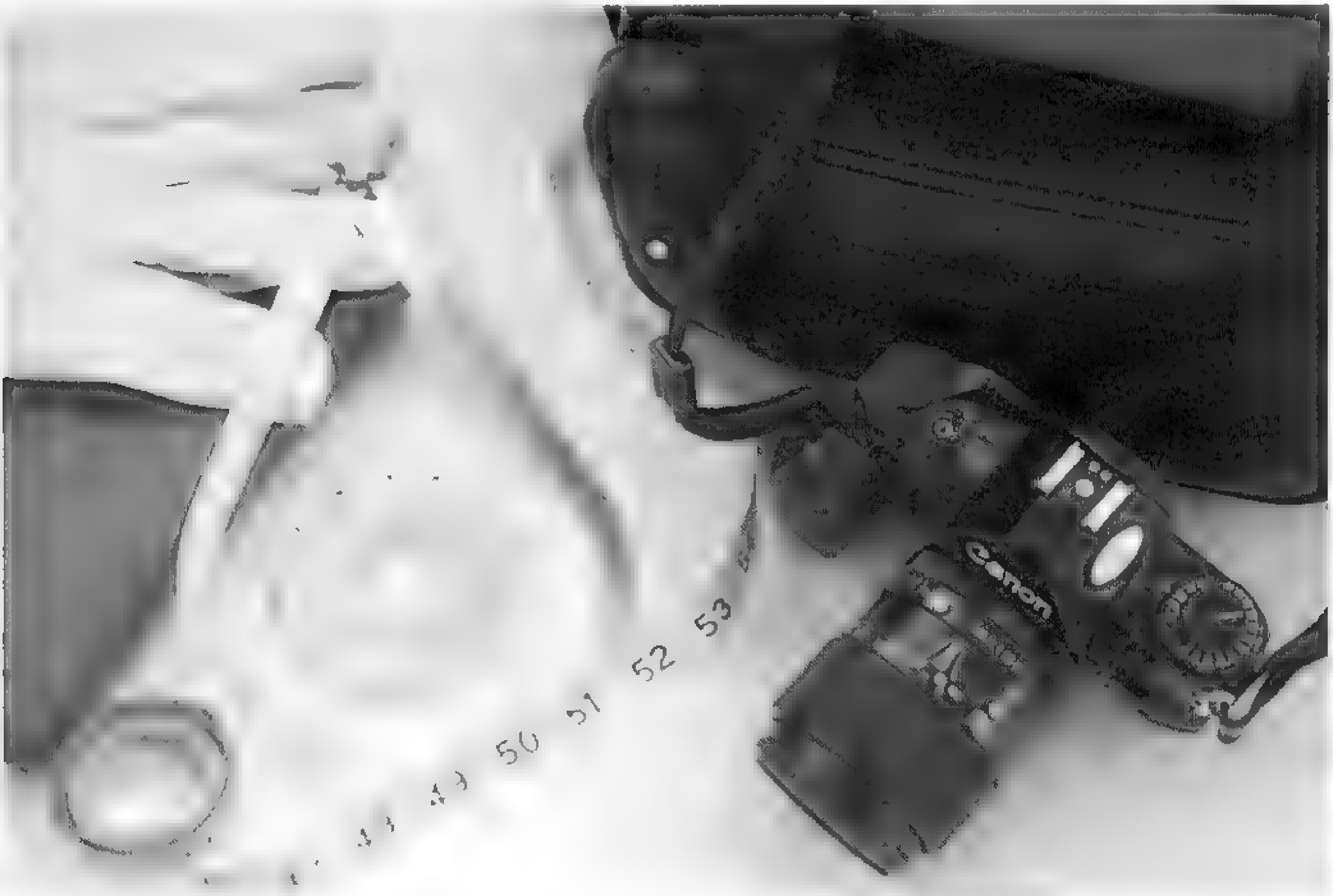


Figure 11.3 A bag of items likely to be needed when visiting a museum is a good thing to have. A notebook is the most important item on which details can be written down along with selected sketches. A camera is likewise useful. Although personal photographs usually cannot be published, they can be exceptionally helpful for private study. A video camera improves on this slightly, recording details in a lower resolution but with far more completeness. Cotton gloves should always be included in case the opportunity arises to handle authentic pieces, as should a cloth tape measure. A small tape recorder is also useful for recording notes through an exhibition when examining a particular piece, or while attending lectures. Several photographs of your work might prove valuable to gain access to museum staff. Finally, always bring a supply of batteries, extra film, and even a tripod when necessary.

Museum List

UNITED STATES

Metropolitan Museum of Art
1000 Fifth Avenue at 82nd Street
New York, NY 10028
212-535-7710
http://www.metmuseum.org

Philadelphia Museum of Art
26th Street and the Benjamin Franklin Pkwy.
Philadelphia, PA 19130
215-763-8100
http://www.philamuseum.org

Higgins Armoury
100 Barber Avenue
Worcester, MA 01606-2444
508-853-6015
http://www.higgins.org

Art Institute of Chicago
111 South Michigan Avenue
Chicago, IL 60603
312-443-3600
http://www.artic.edu

Cleveland Museum of Art
University Circle
11150 East Boulevard
Cleveland, OH 44106-1797
216-421-7340
http://www.clemusart.com

CANADA

Glenbow Museum
130 Ninth Avenue S.E.
Calgary, Alberta
Canada T2G 0P3
403-268-4100
http://www.glenbow.org

GREAT BRITAIN

British Museum
Great Russel Street
London WC1B 3DG
0171-323-8599
http://www.british-museum.ac.uk

Royal Armouries
Armouries Drive
Leeds LS10 1LT
http://www.armouries.org.uk

Wallace Collection
Hertford House, Manchester Square
London W1M 6BN
0171-935-0687
http://www.the-wallace-collection.org.uk

Victoria & Albert Museum
Cromwell Road, South Kensington
London SW7 2RL
0870-442-0808
http://www.vam.ac.uk

GERMANY

Militärhistorisches Museum
Olbrichtplatz 3, 01099 Dresden
0351-823-0

Deutsches Historisches Museum
Unter den Linden 2
D-10117 Berlin
49-30-20304-0
http://www.dhm.de

Weste Coburg
D-96450 Coburg
09561-879-0

FRANCE

Musée de L'Armée
Hôtel National des Invalides
6, place Vauban, 75007 Paris
33-0144-42-37-72
http://www.invalides.org

Musée des Beaux Arts de Chartres
29 Cloitre Notre-Dame
28000 Chartres, France
0237-36-41-39

ITALY

Museo Nazionale del Bargello
Via del Proconsolo, 4 Florence
39-055-2388-606
http://www.sbas.firenze.it/bargello

Museo Stibbert
Via F. Stibbert 26
50134 Florence
39-55-475520
http://www.vps.it/propart/stibbert.htm

Schloss Churburg
1-39020 Schulderns
0473-615241

Doges's Palace
St. Mark's Square, Venice

DENMARK

Tojhusmuseet
Frederiksholms Kanal 29
1220 Kobenhaven, K
33-11-60-37
http://www.kulturnet.dk/homes/tm/collect/intro.htm

AUSTRIA

Office of the Landeszeughaus Graz
Schmiedgasse 34/II
A-8010 Graz
43-316-828796
http://www2.iicm.edu/arsenal

Kunsthistorisches Museum
Main Building A-1010 Wien
Waffensammalung (Arms & Armour Collection)
Maria-Theresien-Platz
Neue Burg, Entrance Heldenplatz
1010 Wien
43-1-525-24-460

SPAIN

Real Armería
Piazza Castello, 191 Turin
11-54-38-89
http://www.comune.torino.it/turismo/spagnolo/mus_armeria.htm

SWEDEN

Livruskammaren, Stockholm
Slottsbacken 3, (Royal Palace) S-111 30 Stockholm
46-8-5195-55-44
http://www.lsh.se/livrustkammaren/home.html

SWITZERLAND

Swiss National Museum
CH-8023 Zurich
41-1-218-65-39

Valeria Museum
15, Place de la Majorie
CE-1950, Sion
41-0-27-606-46-70

and collections do not belong together. They are composite. In the 19th and early 20th centuries, it was fashionable to complete a partially extant suit with similar pieces to create the effect that "might have been" created by the original harness.

Some collections are famous for their composite collections. With a few notable exceptions, harnesses of the 14th and 15th centuries are nearly always composite. There are many hodgepodge collections of pieces from the 16th and 17th centuries, especially in the Maximillian style. Do not, therefore, rely on the dating presented by auction catalogues or of complete harnesses where subtle differences in style in the components can be detected. Read the sidebar descriptions carefully. Sometimes the older armour historians and auction catalogues can be a great help in finding the provenance of particular components of an assembled suit.

Added to this bit of 19th century idealization of the Middle Ages was the demand in the marketplace for armours, particularly for that produced in the 14th and 15th centuries. The rarity of such pieces prompted unprincipled auctioneers and dealers to commission forgeries that were often sold as real to unsuspecting enthusiasts. Samual Pratt, an antique dealer and renowned faker, is the most famous of these offenders.

Not all reproductions are forgeries. During the early part of the century the German Ernst Schmidt owned a workshop that produced thousands of pieces. So long as they are not sold as real but as reproductions, then little harm is done. But many reproductions and forgeries suffer from critical flaws that can be detected after a bit of study.

The first thing to look for are functional components that would not have worked. Eyeslots slanted incorrectly, neck holes that are too small, that kind of thing. Next, look for all those carefully learned elements of style to find those that do not match or oddities that don't seem to fit. With a little practice, you can spot reproductions at least some of the time, although even the experts argue about the best of them

PROJECT RESEARCH

Before any work is begun on an armouring project, you should spend time learning the elements of style necessary for the piece in question. How would you characterize the general shape of the lines used? How are the plates joined? Which segments of the piece are domed and which are flared? How closely do the plates fit? What are the elements of design that the intended combatant might find difficult to fight in? What does the pattern look like? What material is required?

These questions should be answered, at least informally, before you begin. The place to begin is with the books. To make a bascinet c. 1380, for example, gather as many pictures of similar bascinets as possible. Look at them carefully, perhaps attempting to draw one as well.

Although you must not violate copyright law, it is very helpful to place copies of your study photographs in the design and forming areas. I like to make blown-up copies of the study photographs so that the images are nearly life-sized. It gives me a better feel for how the lines interact and enables me to examine the piece's lines in great detail.

When drafting your patterns, when hammering, and when adding details, always look first to the pictures. When you are resting in between hammering passes, for example, peruse the photos again. You will find that, even mid-project, there are many details and subtleties of line that passed unnoticed even through an earlier scrutiny.

The best solution for reinforcing the lines is to actually have an example piece present, either in its real form or as a casting. You can use reproductions for this, subject to the caveat above that all reproductions contain flaws.

Advanced Armourers

You can learn a great deal by talking with other armourers, especially those who you might consider to be in the "first circle." The community of armourers, especially at the more advanced levels, is reasonably small, particularly within the reenactment

community. If you find it difficult to get to the museums, then content yourself with books and examining the pieces of the finest reproduction armourers. It's not as good as the real thing, but it is better than nothing at all.

I will add one serious word of caution here regarding the use of reproduction pieces as models. There is a trend in the reenactment communities for novice and intermediate armourers to base their work not on historical examples so much as the work of other reenactors. Like a photocopy of a photocopy, each generation is successively less detailed and accurate, until over time the overall quality falls. To move a community of armourers forward requires the most skilled of them to set the example by going back to the primary research methods — the books and collections still remaining that show authentic medieval pieces.

Technique Sources

In addition to learning about line and construction details, the armourer can learn a great deal about technique from books on silversmithing. To a lesser degree, works on general metalworking or blacksmithing can be helpful. Most of the work in silversmithing uses hammers that are far too light and wooden stakes that would not hold up to the heavier steels and hammers required by the armourer, but the techniques are the same. You just have to scale them up a bit.

Some local colleges might well have art metalworking or welding classes that can fill out an armourer's skill, teaching forming techniques, soldering and brazing, etching, engraving, or other embellishment techniques. I highly recommend both!

Figure 12 1 Taking accurate measurements will help to ensure that the armourer's final piece will function for the combat form intended since each piece is tuned for the patron's body In this case the armourer uses large dividers to determine the appropriate opening in the cuirass for a patron

Chapter

Taking Measurements

If the armourer is working on a project for a particular client, measurements will be required for each component. Careful attention to details of measurement will affect the quality of the finished piece, in its function if not its form.

I tend to keep my client notes in a single leatherbound book, along with sketches, research references, and the like. The rough measurements for a piece are usually written on the key patterns or on the pattern envelope so that future similar projects can be based on previous work.

Tools for taking measurements are simple: a cloth tape measure, as seamstresses use; dividers or calipers; and paper and pencil. Advanced measurements can be made from plaster casts of a client's limbs or even his whole body, but this is rare.

HEAD AND NECK MEASUREMENTS

Because the head and neck are often addressed in the same defense, appropriate measurements should be taken whenever a helmet is to be constructed. Most people's heads range from 21 1/2 to 23 1/2 inches in diameter, though they vary wildly in the length/width ratio and length of the neck. When the head measurements have

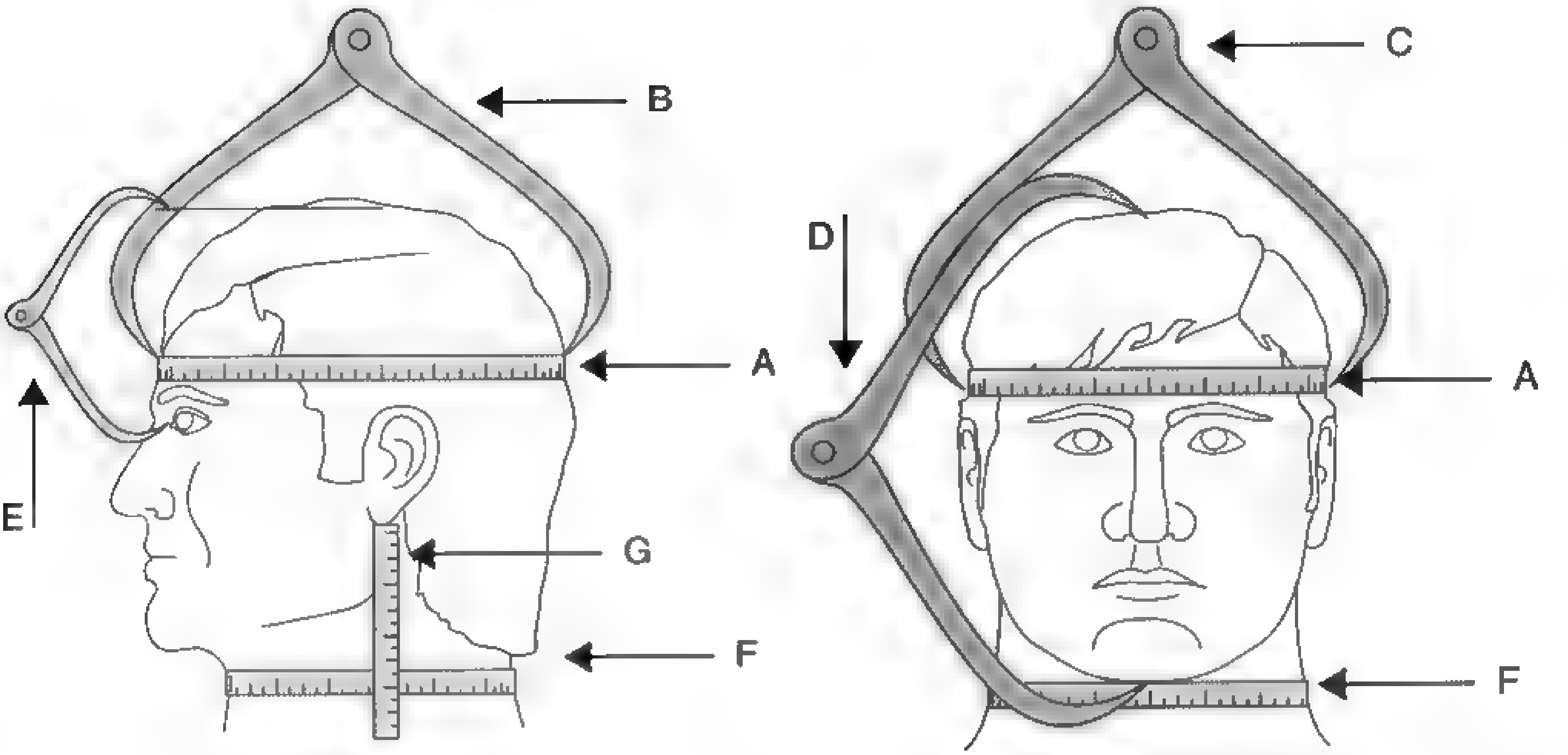


Figure 12.2 Measurements for the head.

been taken, I like to create cardboard templates for the expected interior size for the helmet bowl and the length of the visor.

Measuring the head from the armourer's point of view requires four measurements and three optional possibilities:

A. Head circumference (usually between 21 1/2–23 1/2 inches)—Take this using the cloth tape, measuring around the crown of the head. This will determine how big around the helmet will be and which pattern you choose.

B. Head length—Calipered measurement from the front to back, at the same crown point. Use this measurement to determine how long the helmet skull must be. Allow 5/8 inch all around for padding.

C. Head width—Calipered measurement from side to side, allowing a small amount for the ears. This number will be used to determine the width of the helmet skull. Allow 5/8 inch all around for padding.

D. Head height—Calipered measurement from the top of the head to the chin. This will be used to determine the final height of the helmet and visor.

E. Eye level—Calipered measurement from the center of the eyeline to the top of the head. I like to take this measurement to insure that the occularia lines up with the eyeline when the appropriate amount of padding is used, but it is optional.

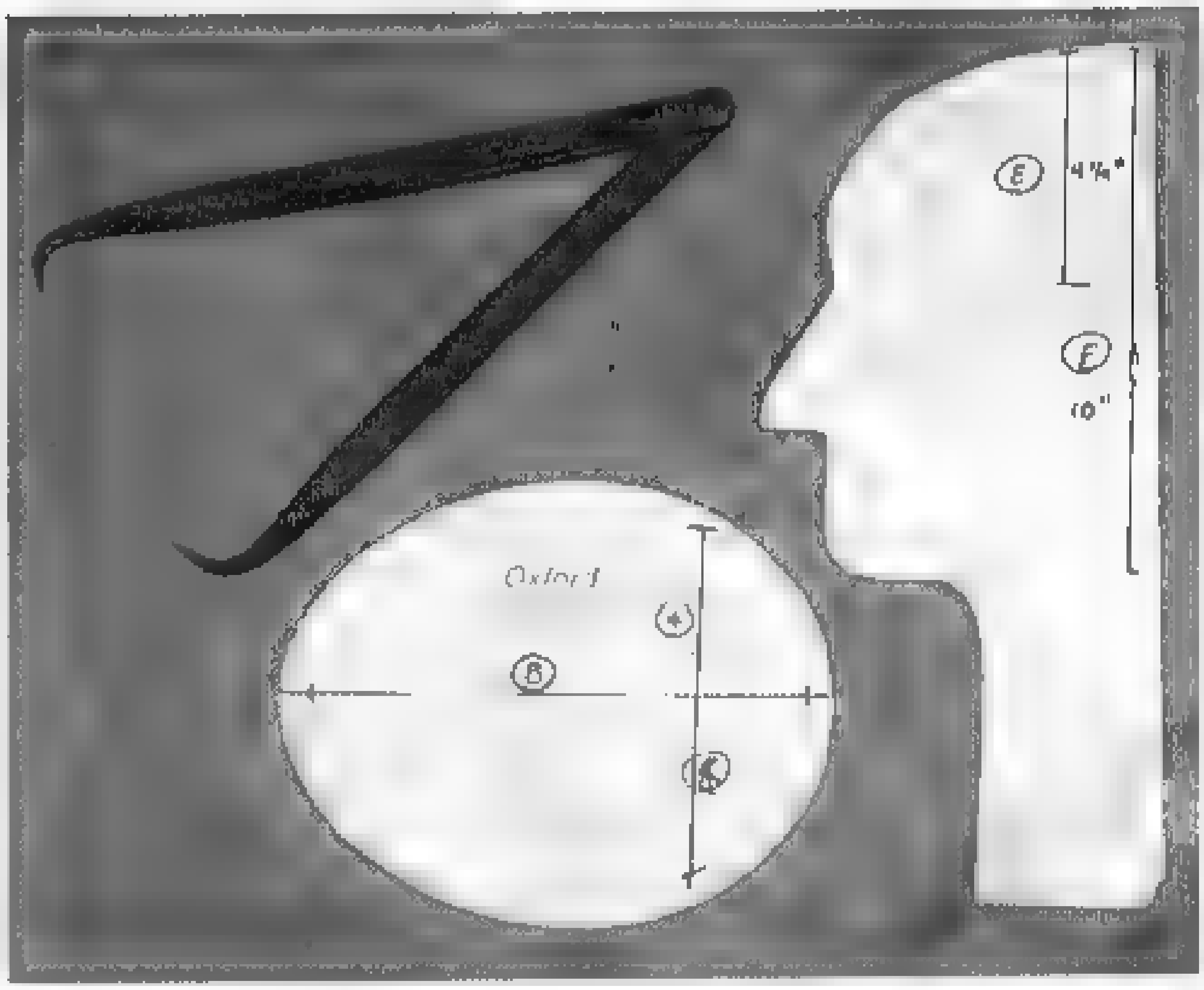


Figure 12.3. Using guides custom cut for each client, the armourer can ensure a good fit for finished pieces.

F. Neck circumference—Cloth tape measurement all around, usually from 15 17 1/2 inches. Use this to determine the length needed for a gorget.

G. Neck height I rarely measure this unless I'm producing a helmet with an attached gorget, such as an armet or close helmet. Normally I would simply note how long the patron's neck is, though in the case of an integrated gorget I will measure the distance from the bottom of the ear to the collarbone.

CUIRASS/BODY DEFENSE MEASUREMENTS

Measurements for the body are similar to those used by seamstresses for regular garments. It is critical to note that not making proper allowance for movement in the breastplate can render the piece all but useless for many combat forms. For all measurements of the body and arm, I strongly recommend taking measurements over the gambeson or arming coat.

A. Chest circumference—Cloth tape measurement around the nipple line. This will determine the overall size of the cuirass.

B. Waist circumference—Cloth tape measurement at the waist, just above the hips. Sometimes an additional measurement at the rib cage is also taken.

C. Hip length—Cloth tape measurement from the bend in the waist to the bottom edge of the fauld line.

D. Arm opening to arm opening—Cloth tape measurement across the chest held in place with two thumbs to determine the cuirass' useful width. Be careful not to cut the cuirass in too much, nor make it too wide. If overwide it will hinder movement and if too narrow it will look wrong and provide inadequate defense for the armpit.

E. Neck hollow to front bend—Cloth tape measurement from the throat's hollow (where the cuirass usually ends) to the place in the front where the patron bends at the waist. The bend will usually determine where the faulds begin and where the breastplate ends.

Optional chest and waist length and width—Sometimes I will take a calipered

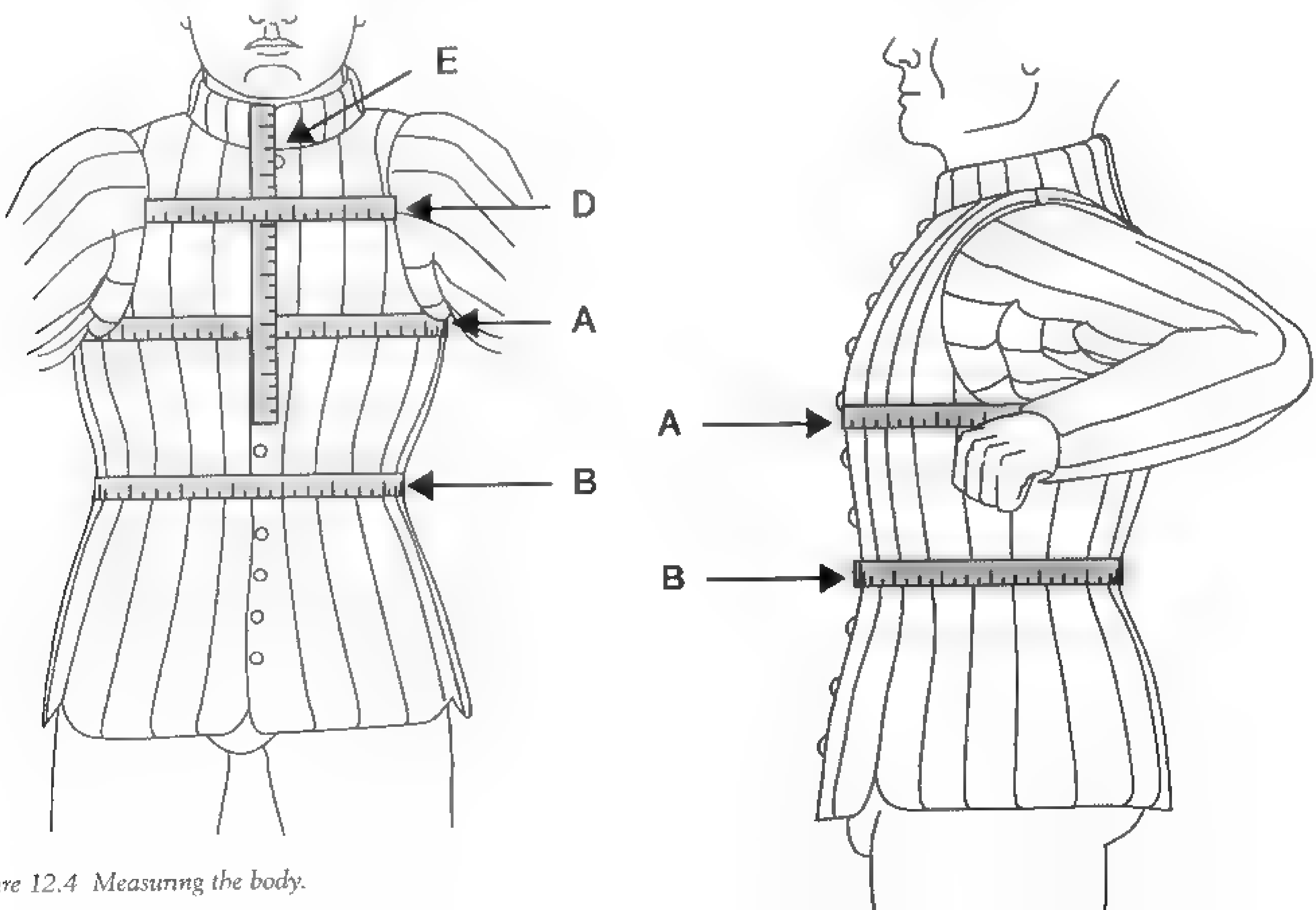


Figure 12.4 Measuring the body.

measurement of the chest and waist's length and width, especially if the patron's body size is in any way unusual.

F. Arm opening to waist—Cloth tape measurement from the arm opening to the bend in the waist. Leave approximately 1/4 of the space from the armpit to the bend in the waist for arm movement. This measurement determines the height of the cuirass from the fauld line to armpit opening.

G. Hip circumference—Cloth tape measurement around the hips. Though rarely taken, this measurement can allow the armourer to relate the width of the faulds to the patron's shape.

H. Shoulder blade to shoulder blade—Cloth tape measurement between the two. This will be a guide in determining the cut of a backplate.

I. Cervical vertebrae to the small of the back—Cloth tape measurement that will help determine the length of the backplate.

J. Small of the back to the lower fauld line—Cloth tape measurement down the fauld line that will determine the length of any rear faulds. Often these faulds cover less than do the front faulds, especially for armour intended for equestrian use.

K. Shoulder point to shoulder point—Cloth tape measurement along the back. Subtracting 10 to 15 percent will yield the approximate width of the cuirass at this point.

L. Neck opening—Cloth tape measurement from each side of the neck. This one can be double-checked to the tip of the shoulder It will tell how wide the neck opening should be.

M. Shoulder point to neck opening—Just a double check that will be used to insure that the pauldron and cuirass interact smoothly.

ARM HARNESS MEASUREMENTS

Inclusive of the shoulder, measurements for the arms are relatively simple. Remember to measure each arm separately, especially for vambraces, as quite often the circumferences are different.

A. Calipered shoulder measurement—Measures the width of the shoulder from front to back.

B. Shoulder point to elbow—Cloth tape measurement from the shoulder point to the elbow. Determines the length of the spaulder or pauldron and rerebrace.

C. Upper arm circumference—Cloth tape measurement that will help to determine the diameter needed for the rerebrace.

D. Calipered elbow—This measurement should be taken while the arm is bent, since the muscles around the elbow press outward at this point.

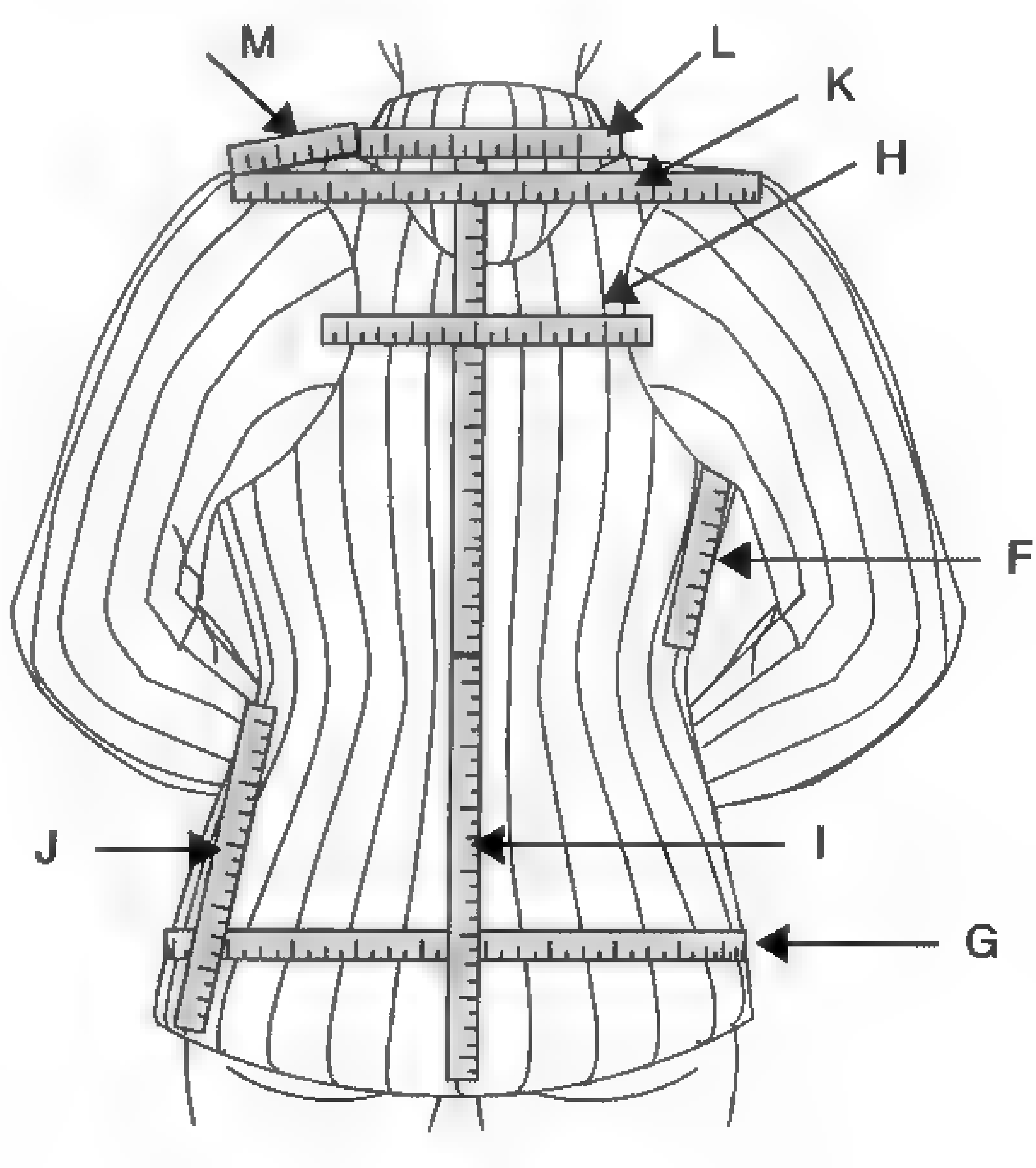


Figure 12.5. More cuirass measurements

E. Side of the elbow to the wrist bone—Cloth tape measurement that will determine the length of the vambrace with lames.

F. Forearm circumference—Cloth tape measurement that will determine the diameter of the vambrace.

G. Wrist circumference—Cloth tape measurement that will determine the diameter of the vambrace at the wrist.

GAUNTLET MEASUREMENTS

The hand is perhaps the most difficult element to measure accurately. The human hand varies greatly in terms of thickness, finger length and width, and ratio of knuckle arc to wrist width, to name just a few. Measurements of the hand should be made over gloves intended to be built into the gauntlet, and for this purpose relatively thin but tough gardening-style gloves are ideal. Black military shells also work well.

Lay the hand flat on a piece of paper and carefully trace around it (fig. 12.7). Mark the knuckles carefully, especially if finger gauntlets are desired.

A. Calipered knuckle ridge measurement –Making a fist, measure across the knuckles.

B. Calipered wrist measurement—From the top, measure the width of the wrist.

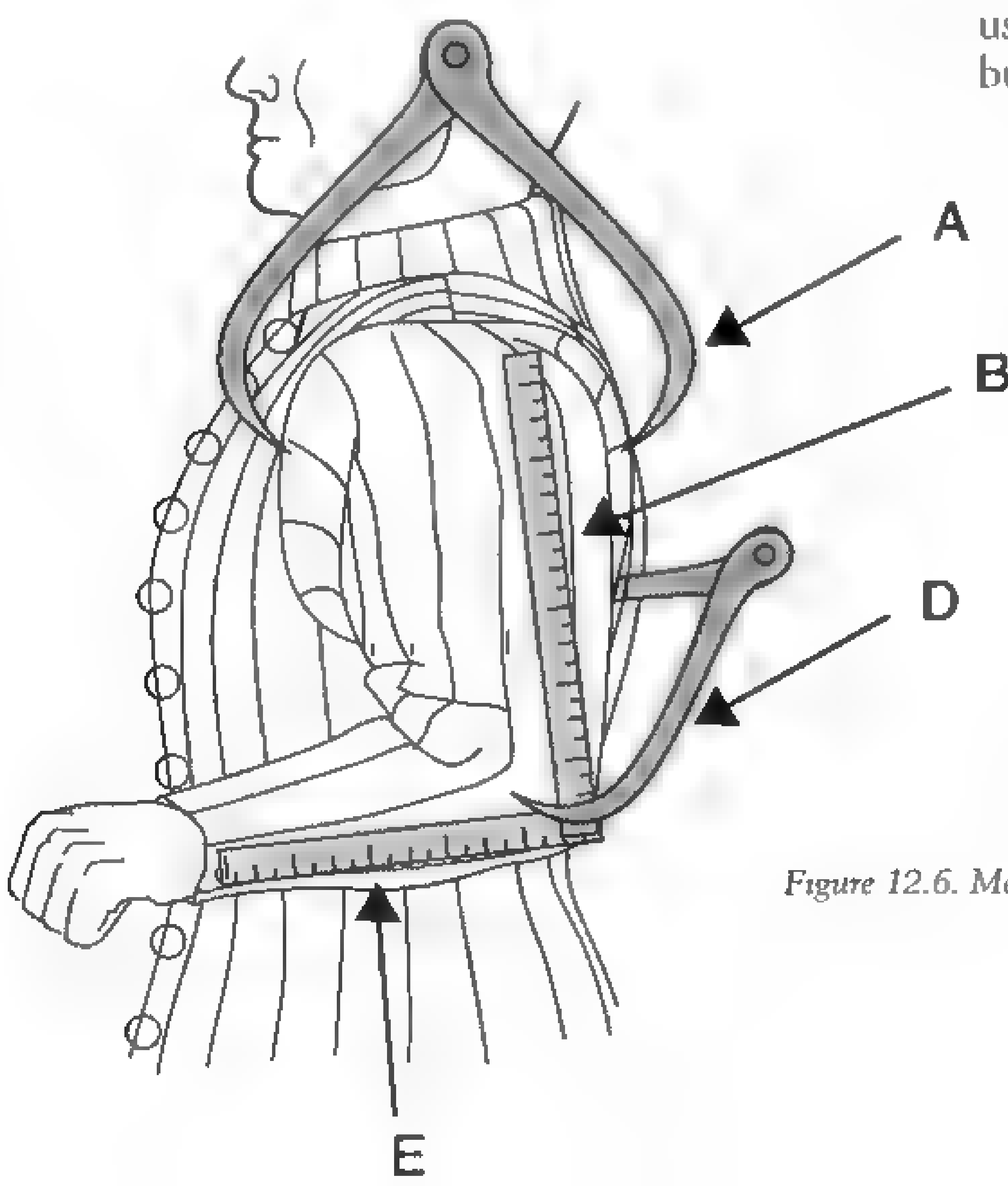
C. Calipered hand thickness—Open the hand and caliper a measurement at the palm, just to get an idea as to whether the hand is thick or thin.

LEGHARNESS MEASUREMENTS

Boots or arming hose of various kinds are often worn by reenactors, so legharness measurements should always be measured over these elements. Ideally, form-fitting boots will be selected since a case-fitted greave requires little or no interference. When taking measurements of the knee, be aware that the thigh muscles swell when the knee is bent, especially when the combatant is kneeling with substantial weight (fig. 12.10).

For case-fitted greaves, it sometimes can be useful to take a plaster cast of the lower leg, but this is not generally required. If this is not done, calipered measurements for the front and side should be taken every 2 inches.

A. Knee circumference—Cloth tape measurement around the knee while standing.



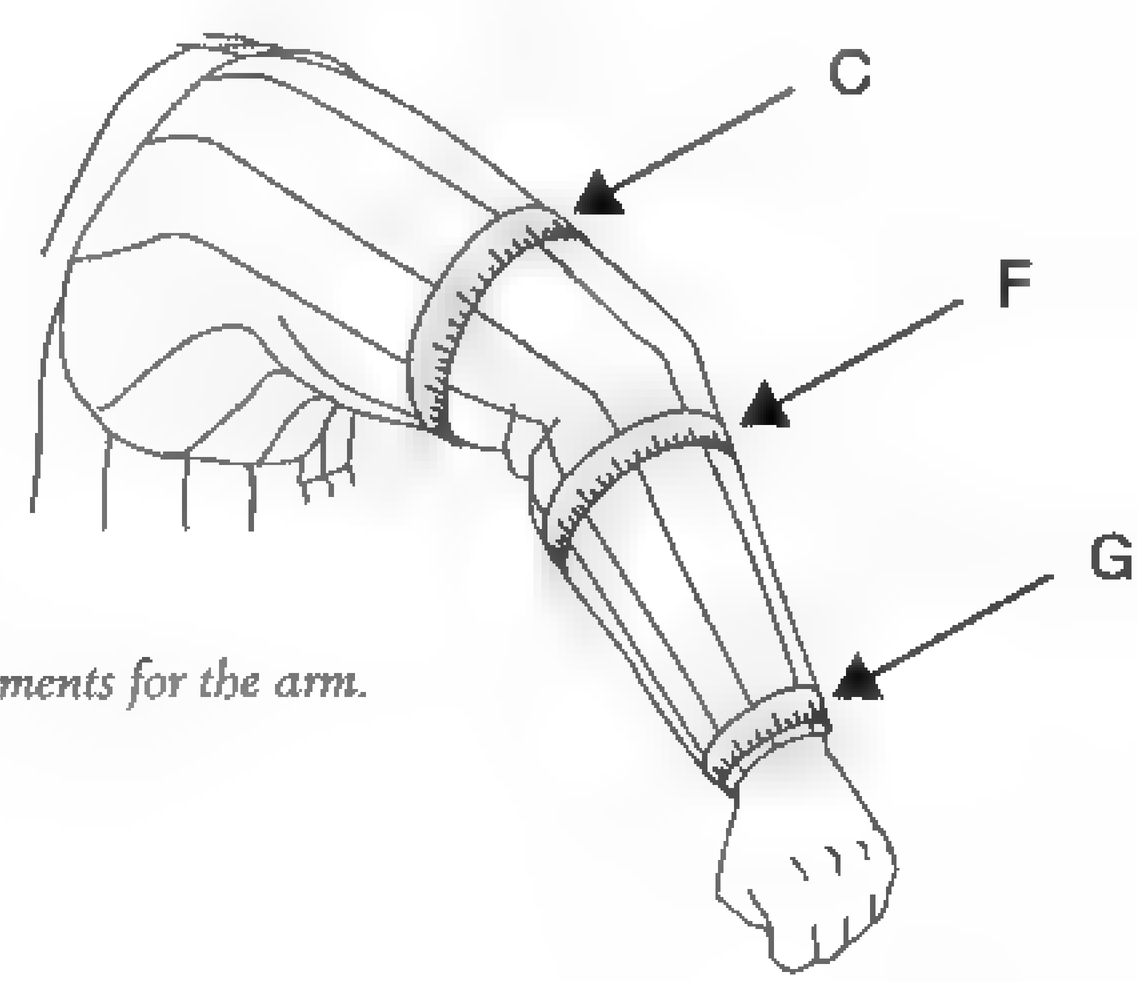


Figure 12.6. Measurements for the arm.

B. Calipered knee width—Mostly for reference, this will help to determine the poleyn's width.

C. Calipered muscle 2 inches above the knee—Taken while kneeling. For combatants who will be kneeling, this is a critical measurement and should replace the calipered knee width for the poleyn design

D. Calipered thigh while kneeling—Ideally this should be taken every 2 inches while kneeling to insure the accurate fit of a custom cuisse.

E. Thigh circumference—A cloth tape measurement around the thigh can replace the detail measurements above for less customized harnesses.

F. Groin to knee—Cloth tape measurement from the bone at the side of the knee to the groin. At least 2 inches should be allowed for the inside of the cuisse.

G. Hip to knee—Cloth tape measurement. While this measurement will yield some clue as to the outside length of the cuisse, the historical examples are important in this regard. As a rule, 14th century cuisses are shorter than those made during the 15th century, when plates were added to improve the defense of the upper thigh and hip.

H. Inner knee to ankle bone—Cloth tape measurement useful in determining the

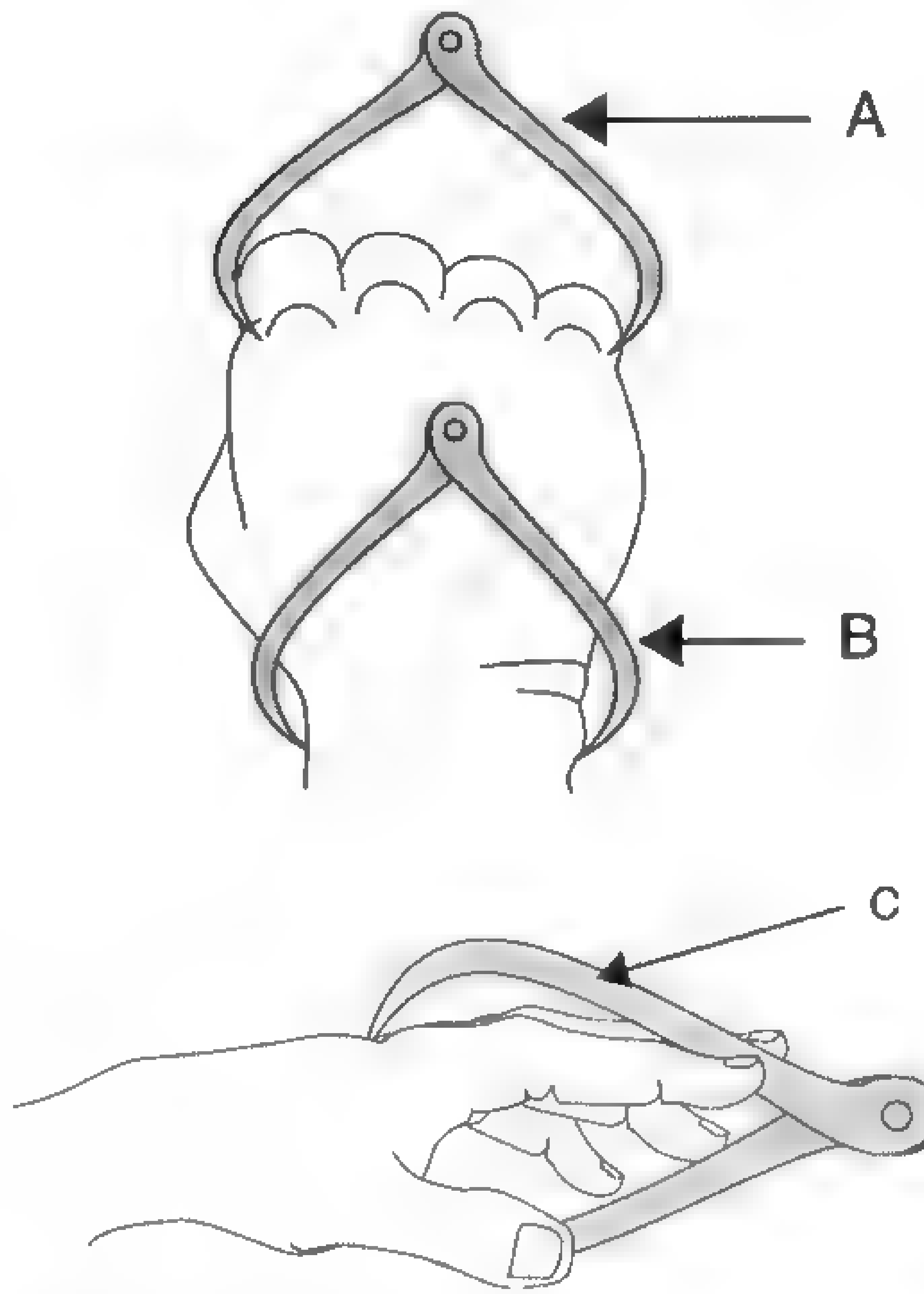


Figure 12.8 Measurements for the hand

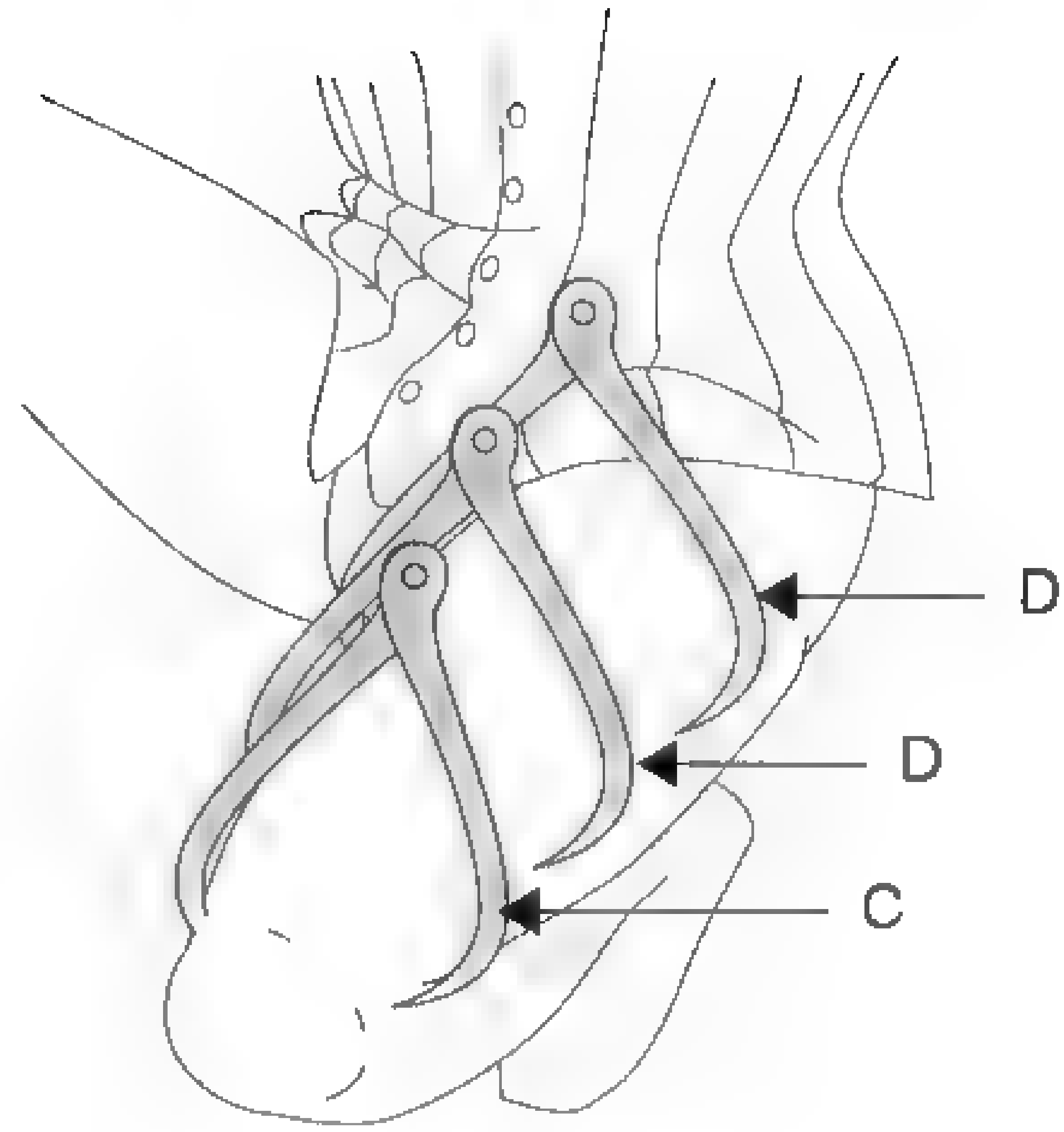
Figure 12.7 Taking a hand tracing

Figure 12.9 Gauntlets are among the most difficult pieces to fit accurately given the range of variation available

length of the greave. Sometimes I also measure from the knee to the ground. Take another one from the outer knee as well.

I. Calipered calf measurement—Ideally, this measurement will be taken every 1 inch so that accurate profile and face templates can be made. Even better is a tracing of the calf done from the side and front, necessary if fully enclosed greaves are needed.

J. Foot tracing—Trace the foot from the front and side for sabatons.



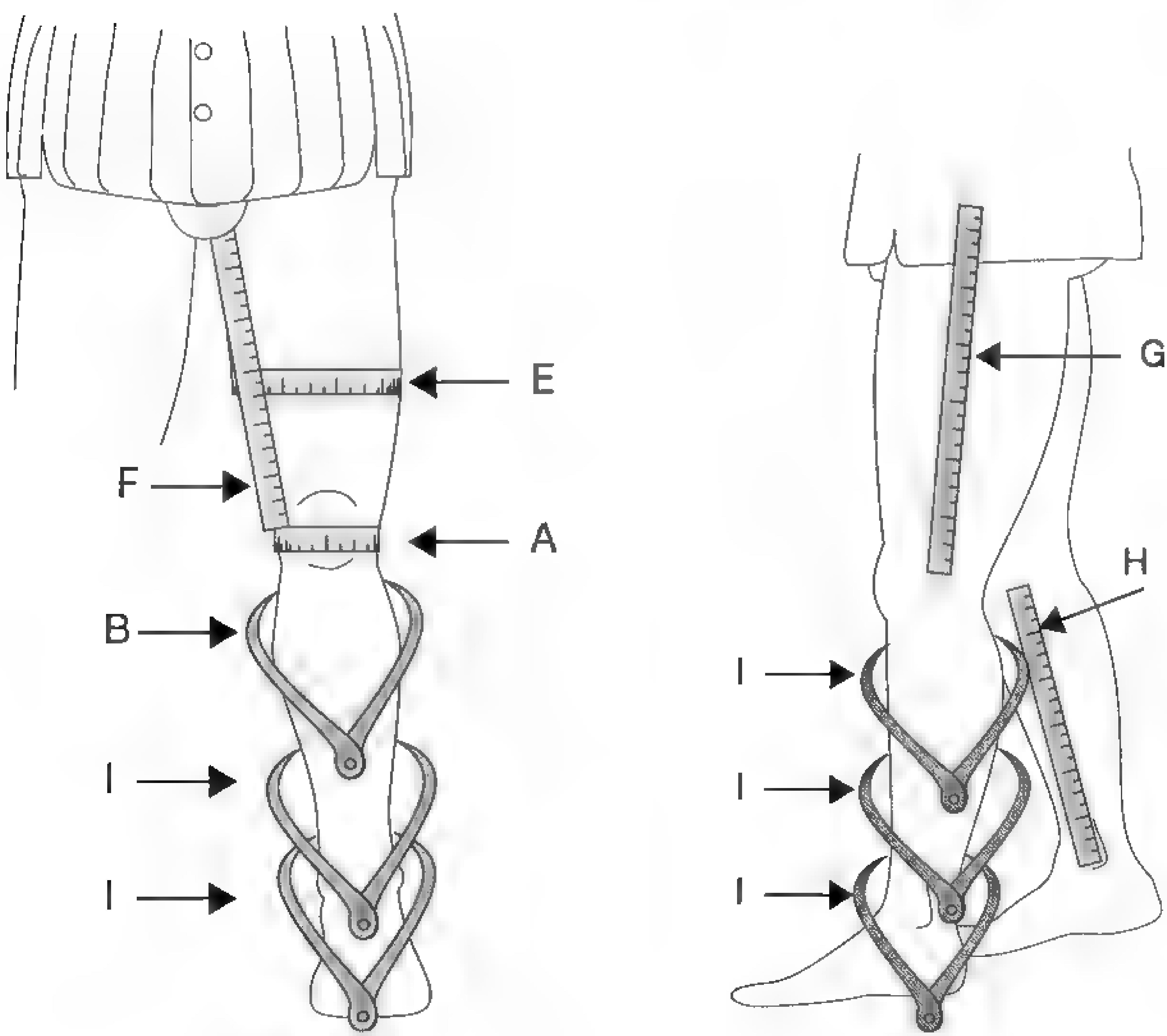
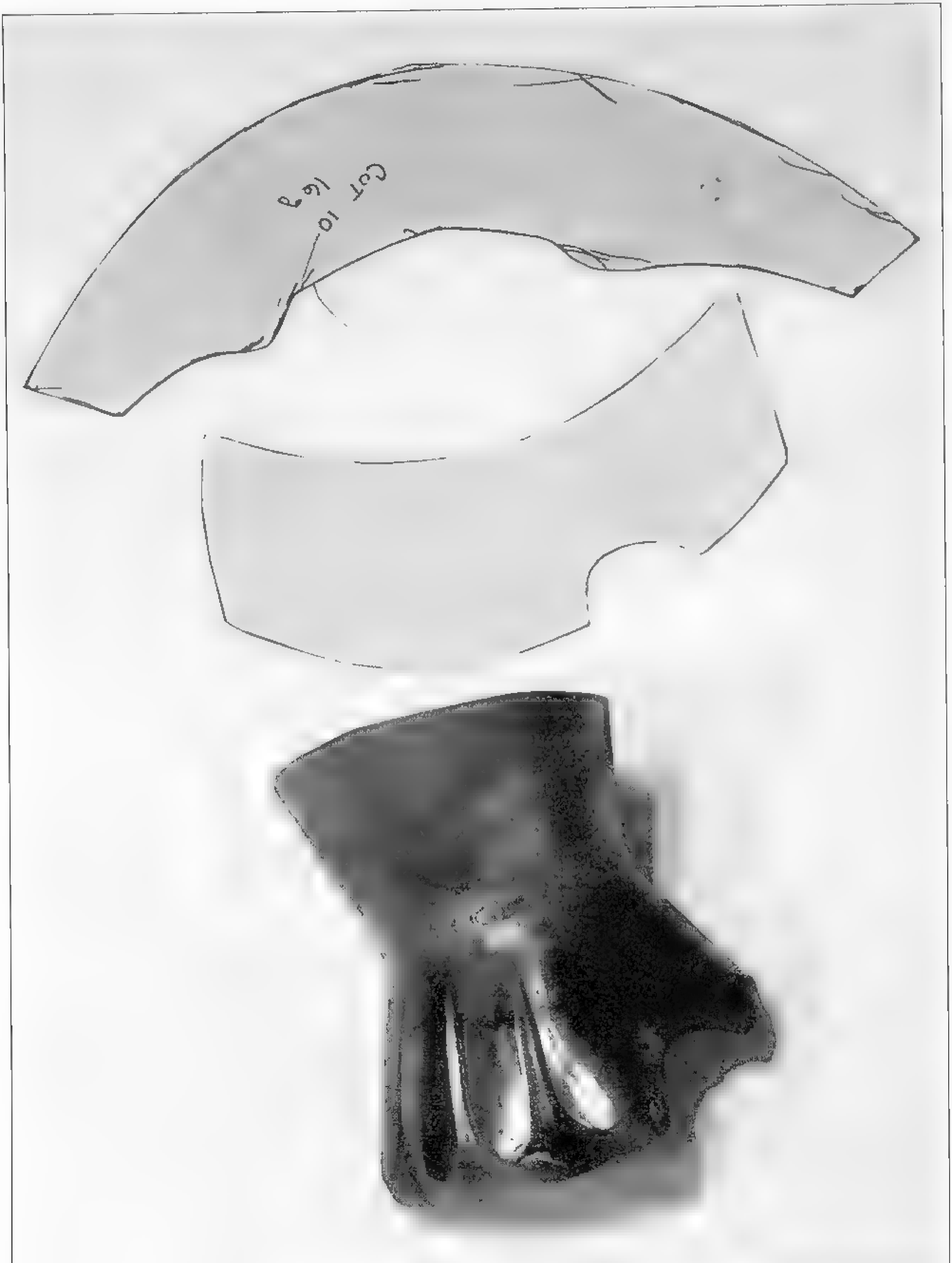


Figure 12.10. Measurements for the leg



Chapter 13

Design, Patterning, and Fitting

It starts as a flat piece of steel. In the end, it is partly skillful engineering, partly insightful sculpture, and partly patient, careful attention to detail. Standing there looking at the steel, one might wonder, "How does it begin?"

Pieces should start life as a vision. This vision can be an impression of what it should be, based on the historical elements of style and the intended use of the final product

Study the references, noting as many elements of style as possible and calibrating the eye constantly as the project progresses. Use primary and contemporary secondary sources —extant pieces, manuscript illuminations, drawings, stained glass, funerary brasses over modern reproductions whenever possible. Note how the pieces are joined, which places are flared and which are domed, what kinds of adornment are done The critically important element to this phase of the project is to fix the image of the piece firmly in the mind's eye. This "fixing" of the image will act as a kind of filter over the armourer's eye, helping him to refine the lines and technical elements as the project progresses.

Next, consider carefully the patron for whom the armour is made. How does he intend to use it? Is it to be used from horseback? From foot? Will the patron be required to kneel in the armour? Run? How does he or

Opposite page
Figure 13.1 Patterning is where the armourer's sense for the metal and interpretation of the medieval lines come together. Individual style is imbued into the patterns, representing a basic expression of the armourer's interpretation of his art. It is likely that medieval armourers made little use of patterns beyond rough forms that were forged hot and later ground. But for modern armourers with access to homogenous steel of uniform thickness, patterns represent a valuable source of knowledge and consistency

other combatants deliver blows in the list? What weapons will be used against the patron, and what weapons will the patron wield?

Considering the use of the harness and the character of the patron will help to determine what the lines and functional elements of the piece should be. Does the patron like a harsh, warlike approach or something softer and more humanist? These kinds of factors can be included to make the lines of a piece harsh or soft.

CONSIDERING COMPONENT INTERACTION

To provide a man-at-arms with adequate mobility while simultaneously providing defense against the weapons he will face requires a carefully wrought interaction of many components that must work smoothly together. Pauldrons and spaulders, for example, must not only allow for movement of the arm and provide defense for various parts of the shoulder, they must also move in relation to the cuirass and the rerebrace. The rerebraces, in turn, must allow the pauldrons to move while moving under the couter.

Some patrons and forms of reenactment combat create special problems. Rule sets for specific reenactment groups must always be taken into account, a fact that sometimes limits an armourer's freedom with respect to openings in the face, how the fingers are defended, or how joints work. Similarly, some patrons have unique fighting styles unlike those found in the Middle Ages, so some elements of historical design might be eschewed for more sport-functional pieces. I do not personally advocate this practice, but it is a reality of the marketplace faced by armourers working in these communities, and as such it must be accounted for.

These things should be known in advance, but if they are not the problem can be reduced by trial-fitting the very rough-formed pieces

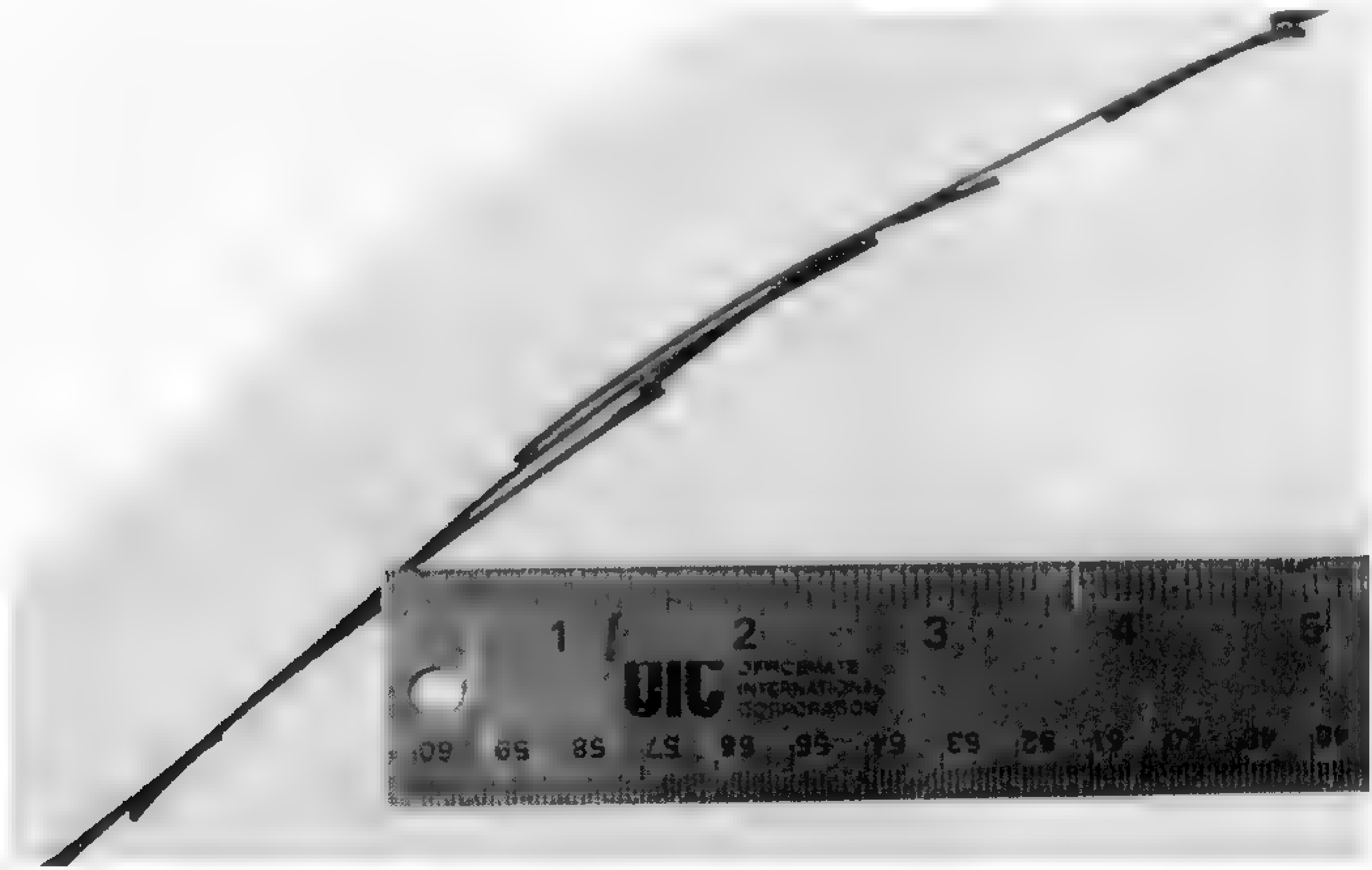


Figure 13.2 Large round, triangular, or square rolls require a good deal of metal to be added to the pattern, sometimes as much as 2 inches.

onto the patron before the final finish and assembly is done.

Whenever possible, the pattern for a piece should be drafted with the references and patterns for the related elements close at hand. A gauntlet cuff, for example, is based not only on the circumference and shape of the metacarpal's baseline but also on the size of the vambrace over which it must move. Having both at hand gives the armourer a starting point.

ENVISION HOW THE PIECE WILL BE CONSTRUCTED

The next step is to determine how you will construct the piece based on your experience, the patterns available, and the level of authenticity required.

Allowances for Rolled Edges

If you have an edge that must be rolled, leave at least 5/8 inch of exta material. For large rolls, you must leave as much as 2 inches depending upon the style of the roll that is appropriate. Square and triangular rolls, for example, require a lot of material, while a large round or roped roll requires somewhat less. And remember also that material can always be removed, but it is difficult to add.

Draft the First Copy of the Pattern

Once these considerations have been decided and the interfacing pieces and reference examples are at hand, you can draft the first version of the pattern. Pattern-making is an iterative process where continual refinement should be sought. Oftentimes I will go through several cardboard patterns trying to fit the piece, always making extra allowance for the thinness of the pattern material and leaving extra at the edges for trimming.

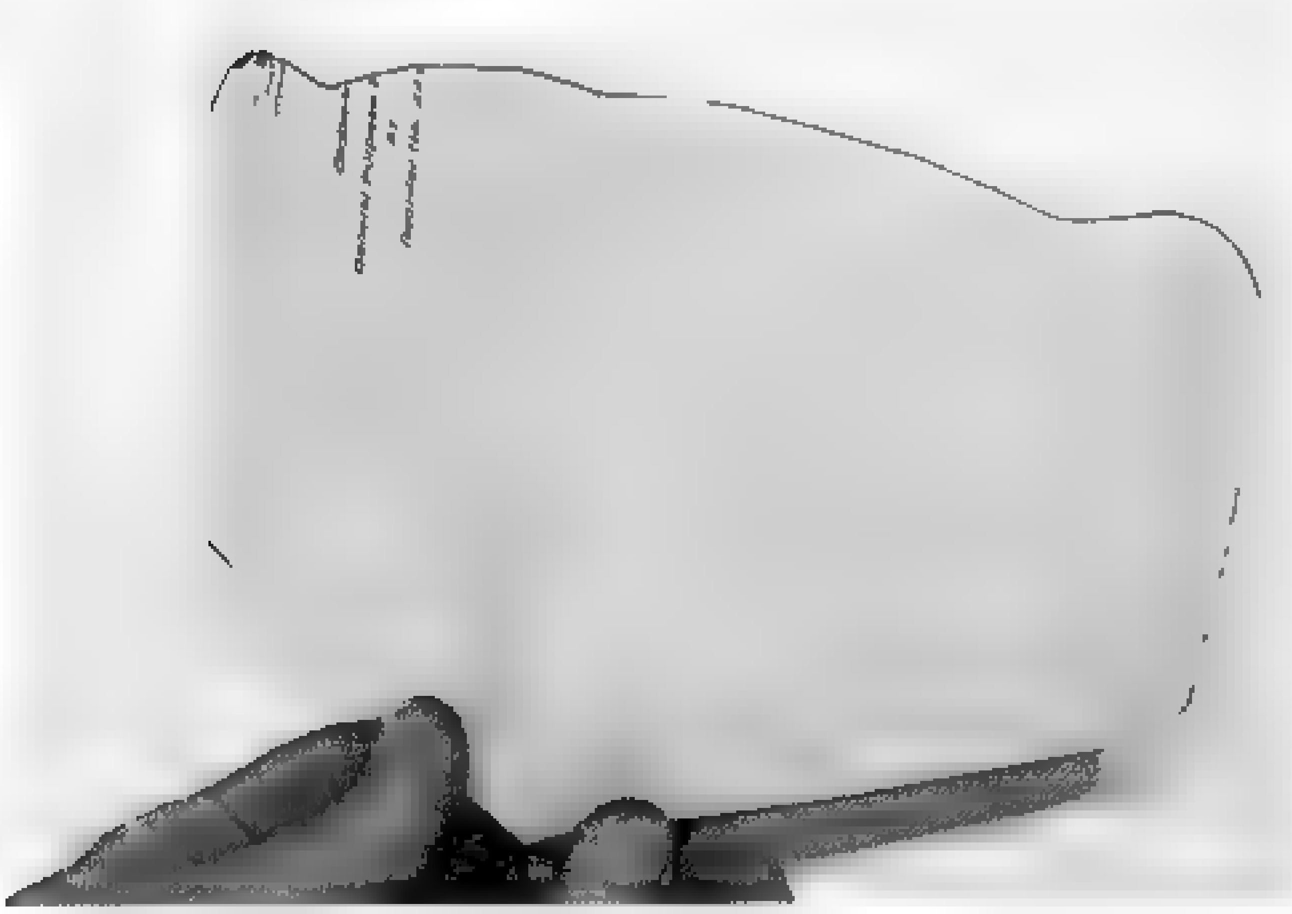


Figure 13.3. File folders make ideal pattern material not only because of their rigidity but also because their strong central ridge makes drafting symmetrical patterns relatively easy.

The Pattern File

I keep my patterns in a single filing cabinet, each project that is even slightly different from an older one kept in a separate 9 x 12 envelope. Each envelope is marked in the upper right with the project, the client, and most importantly, the date. On the cover of the envelope I make notes of problems and observations made throughout the project. Months or even years later, if I come back to make a similar piece, these notes are readily at hand. All of the cardboard patterns remain inside the envelope, each one marked in pen to identify what it is.

Pattern Material

I use manila and colored file folders as the base stock for patterns. They are relatively stiff, easily cut with scissors, and can be thrown away or recycled without worry. Most important is the central crease of the file that is exceptionally useful for basing a centerline. To maintain symmetry, I generally draft only half of the pattern, the center of the piece coincident with the fold. When cut out and opened, the pattern should be symmetrical.

A caution: thin-stocked cardboard does not have the thickness of even the thinnest armoured components, so patterns that you draft in this way must take the thickness of the metal into account.

For patterns that have long-since been perfected, printer's or lithographer's metal plates—often available as scrap from print shops—can be used. Trace the pattern out carefully and cut it out neatly with aircraft snips.

Making the First Draft

The easiest thing to do is to start with a

similar pattern and modify it for the new project. Maintaining your old patterns in an orderly fashion will help this process, allowing you to reference earlier work when starting a new project. You will find some patterns in this book, but you might well obtain others from other armourers.

Armourers who rely on their craft as their primary source of income might be reluctant to offer patterns, as they are often viewed as a kind of trade secret. As a courtesy, another armourer's pattern should never be reproduced for profit without his consent or permission because it contains the roots of a piece's line that have been devised by the original artist. Similarly, there is a right pattern for making historical reproductions, but the pattern itself in this case usually represents substantial investments of the armourer's time in working it backward, so the same rule applies. That being said, many armourers will be happy enough to offer patterns for limited, personal use provided that they are not circulated.

Remember too that in reproducing an armourer's pattern you are also reproducing his mistakes; look carefully at his execution of the piece to see what needs to change. Very few patterns are perfect.

Always leave extra margins at the edges. For articulations, cuisses, and the faces and lower edges of helmets, it is usually (though not always) easier to remove metal than to add it. To add a rolled edge, you need a minimum of 3/8 inch up to 1 1/2 inch depending upon the size of the roll, so don't forget to allow for this as well.

If you are patterning lames for articulations, it is usually better to draft the patterns one at a time, because most lames are slightly different. Each successive lame in an articulation, for example, is slightly shorter because the "hoop's" diameter is slightly smaller. Also, do not place holes in the pattern until the pattern is proven. I articulate each lame individually, since the forming techniques I use are largely hand-done, and each varies enough to make exact reproduction of pieces very difficult.

Sharpness vs. Roundness—Making a "Crisp" Piece

When approaching corners, plan for sharp corners in the pattern and then round them ever so slightly to give the impression of a crisp resolution while removing the dangerous point (fig. 13.4).

Update the Pattern as the Metal Pieces are Made

As you form the pieces, make marks on the pattern. Did you leave enough metal? Is there too much? Modify the pattern or make notes for future reference so that the lessons learned during the project are not lost.

Redraft the pattern as the piece is completed, based on experience earned during the project. The best thing to do is to draft your best guess for the next generation, accounting for what you have learned. Do this even if you don't intend to make another one for awhile, because it will give you a good place to start when you reconsider a piece of this type far into the future.

SPECIFIC ELEMENTS

Each armoured element demands unique consideration, especially for the novice or intermediate armourer. Following are aspects to think about and rough guidelines

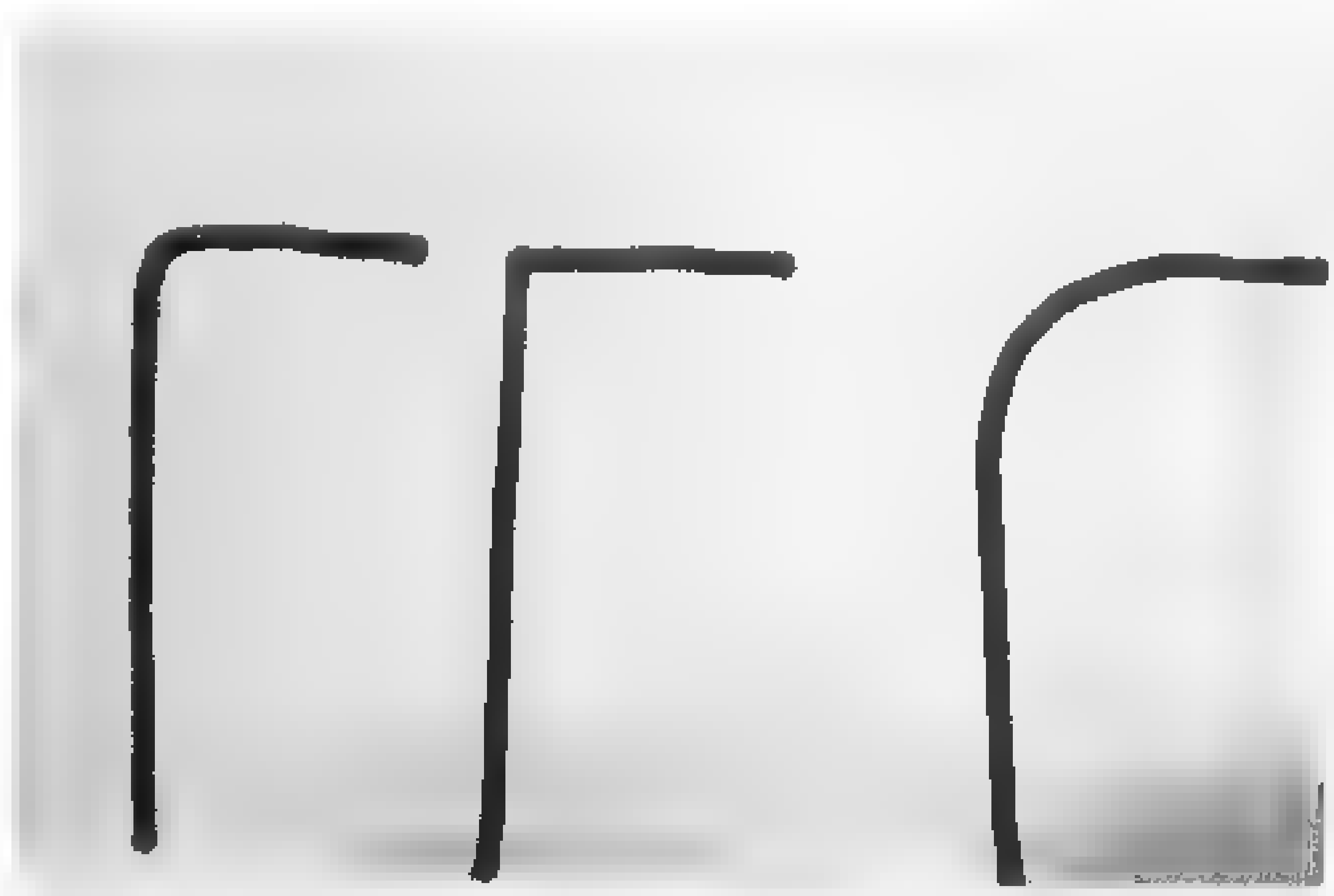


Figure 13.4. Although sharp corners should be avoided, too much rounding (right) conveys a fuzziness to the piece's line and is not a medieval solution. Instead, points on the pattern can be left and then carefully sanded to leave the impression of a point without the sharp edge, as with the example at left.

appropriate to patterning various pieces from the 14th century.

Helmets

There are two main ways of constructing helmets: through "construction" using rivets or welding, or via "raising," which involves making the skull in a single piece.

The simplest helmets are made using the constructed techniques, individual plates held together with rivets. There are helmets from the 8th through the 14th centuries that are made in this fashion, and if done well, an elegant "heaume" is a useful and easy project for novice armourers.

More complex are helmets where the skulls are made of butt-welded pieces or with lap-welds done on the forge. Normal conical helmets, bascinets, and all helmets of the 15th century feature smoothly shaped skull regions that can be replicated through welded construction. Because the plates are often relatively thick and gas-welding techniques are normally used, some gapping in between the plates is generally acceptable.

Constructed helmets must be sized carefully because they are sensitive to small changes in the patterns that can drastically alter the finished size. Helmets that consist of a variation on the casque tend to be constructed from two pieces. Spangen helmets are generally created from a variety of straight strips or teardrop-shaped components riveted together. Bascinets, when constructed, can be made either from two or three pieces (the three-piece pattern is presented in detail in Chapter 30). Sallets are sometimes done in two pieces and other times three, the skull and skirt sometimes being separated.

With helmets raised in one piece this is less of an issue, although sizing during the forming process can be extremely challenging. Patterns for raised pieces tend to be rectangles or circles that have had a face opening roughly clipped out to use as a guide, the size being determined by the final dimensions of the helmet.

Raised helmets are the historically accurate way to create at least the finer helmets, but there may be evidence that some medieval pieces started as a forge-welded cone and then raised into the final shape. Charles Davis has started such an experiment with a late 14th century bascinet, and the results are promising. The characteristic high point seems to be an artifact of this technique, where a weld is laid down the center of the cone at the back.

Most helmets, especially sallets, armets, and barbutes of the 15th century, were probably raised without recourse to forge-welds. For novice and intermediate armourers, the constructed technique will serve as a method of creating pieces while the technical control and refinement of the eye are learned in sufficient measure to allow for the use of more authentic medieval technique.

Cuirasses

The patron's measurements are exceedingly important for the creation of a cuirass. For brigandines and coats of plate, as were popular during the whole of the 14th and into the 15th centuries, these measurements are less critical because of their flexibility.

For breastplates, the baseline pattern should be started with and then modifications made in order to size the final piece to the patron. In so doing, the armourer must sometimes split the difference between the patron's measurements and the ratios that are allowable in a given style. The patron gives up a little mobility and the style emerges as less than pure, but the resultant compromise is often a more readily palatable option to a correct but largely nonfunctional piece.[3]

For breastplates and cuirasses, two elements are of particular importance. First, the mobility of the arms is provided by proper cutting of the arm holes. Sufficient allowance for the appropriate rolled edges is important, and on breastplates of iron or steel the arm and neck openings are always rolled. For breastplates covered in cloth or leather, the soft material rolled over the edge provides this same protection. The second major concern is that the breastplate bends at or above the patron's waistline. It should extend upward to the hollow of the throat and downward, flaring

or terminating in a rolled edge at or above the bend in the waist.

Fourteenth century breastplates tend to be shorter than cuirasses of the 15th and 16th centuries, while coats of plate often extend below the waist bend line, relying on the movement of the small plates to provide the required mobility.

Arm Harnesses and Shoulder Defenses

The arm harness actually varies only a small amount for the various types of plate defenses. The vambrace and width of the couter are actually the most critical elements.

Remember that the length of the vambrace will relate to the measurement of the elbow, lower lames, and rolled edge at the wrist. (For this small roll, add approximately 3/8 to 1/2 inch.) I like to complete the rough couter and lower lame before adding the vambrace because it will make up the balance of space needed.

Vambraces should always be rolled at the wrist and, if appropriate, at the opening of the elbow to reduce the risk of receiving a cut. Medieval examples are always thus provided.

Couters are usually formed from a single piece of metal domed or raised to shape. Unfortunately most elbow defenses after 1350 are deep enough to warrant raising or construction in more than one piece. As with other components, the one-piece construction is preferred, but multiple-piece patterns are expedient and less expensive.

At the bottom end, some couters are formed from a single piece with a dart removed. This couter is domed, overlapped, and riveted into place. I have also seen some variant patterns where the couter is formed similarly and the joint welded rather than riveted, but I haven't personally tried it.

Gauntlets

Patterning a gauntlet to fit a particular hand can be difficult, and I usually recommend cutting the pattern a bit large and then forming/trimming down to the required fit. At the lower end, cuffs are usually attached with rivets to the metacarpal, which is the plate that defends the back of the hand. On intermediate-grade productions, the cuff is either riveted or sometimes welded to give the impression of a more difficult single-piece construction, and in the most accurate reproductions the cuff is either riveted or raised from the same piece as the metacarpal, depending upon what is historically appropriate.

Legharness

The legharness actually encompasses everything from the hip down to the greave and sometimes includes the sabaton, the plates that defend the foot, or "iron shoe."

Cuisses are generally taken from a single sheet, though there is almost always a roll at the upper edge, so this should be allowed for. Poleyns—the "cop" that defends the knee—is generally fitted with some kind of defensive wing embossed, flared, or fluted for strength. The appropriate decoration varies with the period, and care should be taken to select the right treatment for the piece based on historical practice.

Poleyns are generally created from a single piece, raised to the appropriate depth. Less authentically, they can also be constructed, a weld used along the median edge. Shallow poleyns, which were used in the 13th and early 14th centuries, can often be domed completely.

Greaves are perhaps the most difficult elements to form because of their assymetry and complex curved surfaces. Historical greaves were always made in a single piece, though I have experimented with various two-piece patterns for the greave front designed for ease of construction to encourage their use within various reenactment groups. A sample is made in detail later in the book.

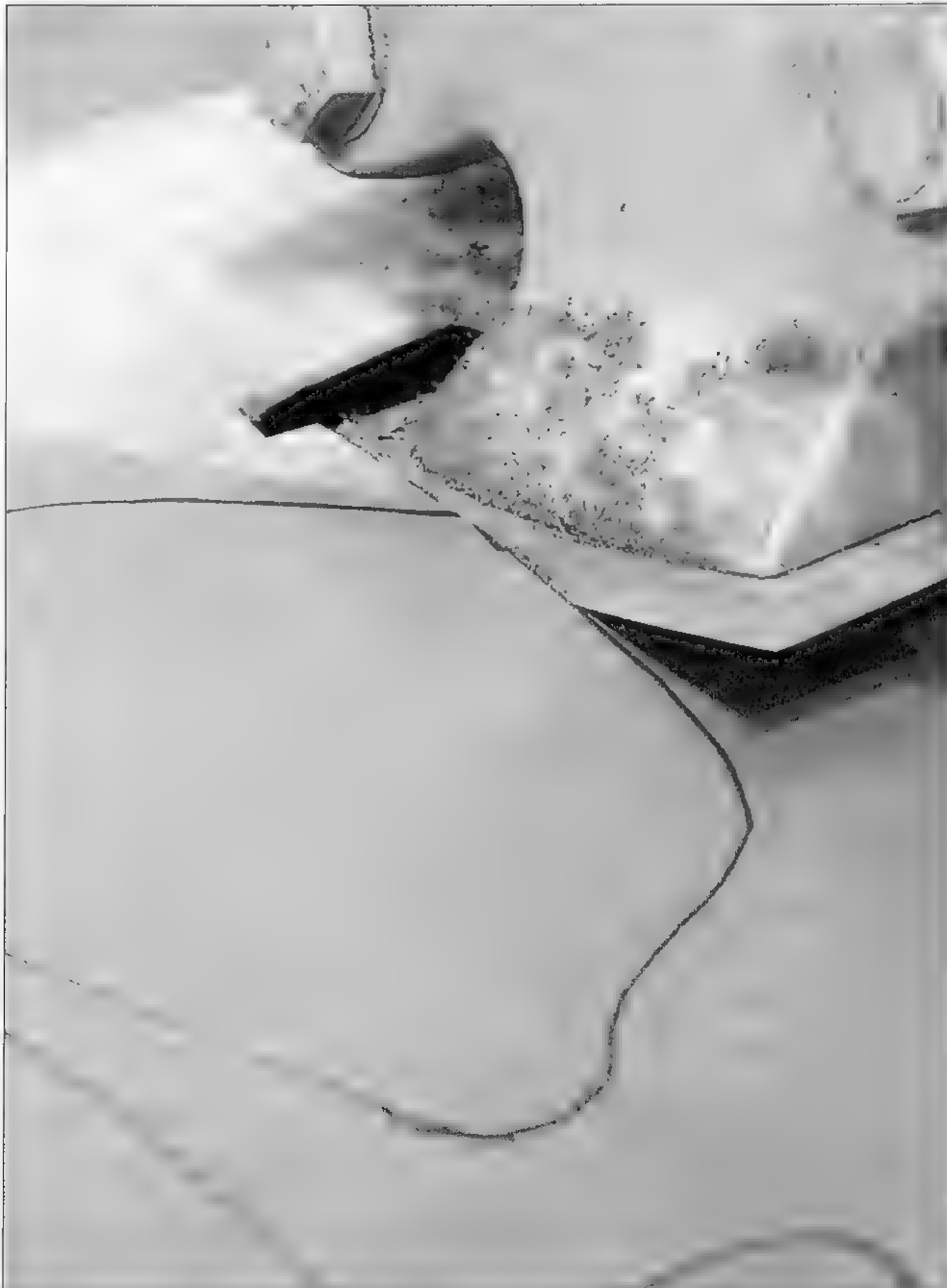
ENDNOTES

1 A primary source is generally accorded to be an authentic artifact, while a secondary source is a contemporary representation or description from art literature, or records. While the latter are useful, they must also be regarded with some degree of suspicion since they add a level of interpretation

2 I believe that skilled armourers should act as expert consultants for their clients, and as such it is more than useful for them to be at least passingly proficient

with the weapons and armoured forms they create. Additionally, I believe that armourers should press back on their reenactment patrons a bit to create pieces that will work in the chosen forms of sparring and still be historically accurate. This is a difficult balance to achieve, but I believe it is a worthy goal.

3 The piece would probably have functioned for the use that it was originally intended. Many functional problems for correctly recreated harness elements relate to the decidedly modern fighting techniques that have evolved and the expectations of extreme mobility required for modern sports.



Chapter

Cutting and Deburring

The objective for the cutting phase of a piece's construction is to accurately duplicate the pattern in metal and deburr the edges before forming begins. The edges must be quickly deburred to remove sharp spurs that can cause injury and turn into cracks as forming progresses.

TRANFERRING THE PATTERN TO THE STEEL

Once the pattern has been selected, it must be transferred to the steel. Normally this is done with a permanent marker, although the medieval equivalents of chalk or lead may also be used. If lead is selected, gloves should be worn and the hands washed before any food is ingested, as it is poisonous.

Use caution at this stage because if the pattern has been sized exactly, the width of a permanent marker line, as much as 1/8 inch, can potentially add as much as 1/4 inch to the size of the finished piece. While this is not a great difficulty if accounted for, it can be quite a surprise when working on components of a joint that have been patterned precisely.

In general the final piece of metal should conform exactly to the pattern. I generally cut to the middle of

Opposite page
Figure 14.1. Cutting a gauntlet from a piece of sheet mild steel. The Beverly shear provides precise, flexible cutting that is unmatched by any other method.

the line, filing or sanding to the inside for a precise fit.

When a pattern includes tight turns, pieces should not be laid out "nested" because they will prove extremely difficult to cut apart using the shear. For small pieces, I strongly recommend leaving extra metal to serve as a handle during most of the cutting process to save wear on the hands.

CUTTING

Once the pieces are laid out, they can be cut out using a shear or jigsaw. Most armourers use a throatless Beverly shear (fig. 6.7) because of its solid manufacture, ease of use, and versatility. Using a Beverly, you can cut everything from a quarter to huge sheets, turning the piece as necessary to create very clean and precise cuts.

Adjusting the Shear for the Metal Thickness

Beverly shears cut best when the distance between the two blades is tuned exactly. Use a metal shim gauge to adjust the blades between uses, or set them for a "general" cut of 16 or 14 gauge, adjusting them for thinner or thicker material. This is done with a common Allen wrench.

When shears are too far apart, a lip can be formed on the metal, resulting in a very sharp, ragged edge (fig. 14.3). When the shears are too close together, cutting will prove very difficult and may damage the blades.

Barstock should never be cut in a Beverly, as it can easily nick the blades. Damaged or worn blades can sometimes be resharpened at Beverly Manufacturing, though if the damage or wear is too great then the blades must be scrapped.

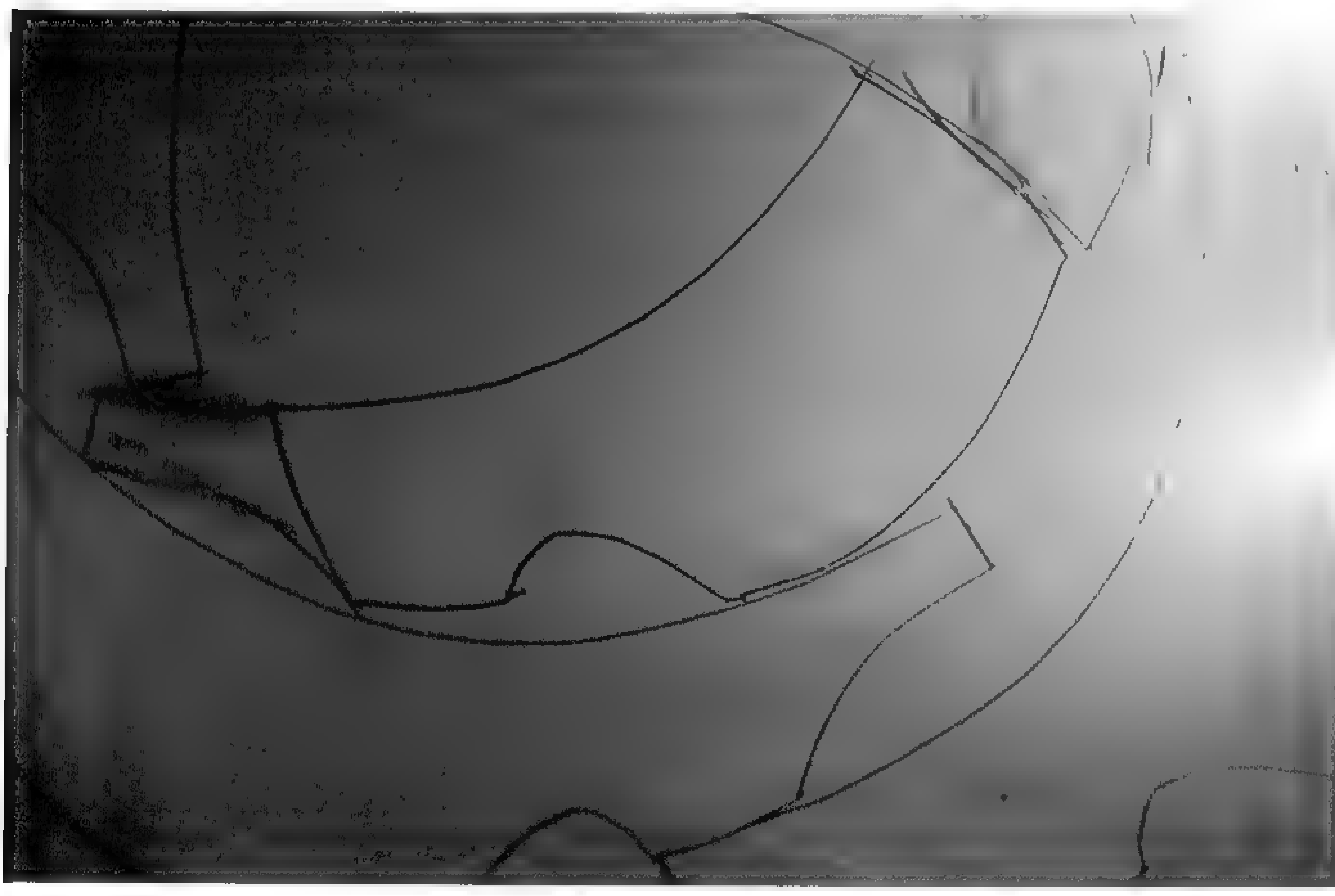


Figure 14.2 Gauntlet metacarpals arranged with a balance between conservation of material and ease of cutting. Mild steel is so inexpensive that it is probably more efficient to spend on the steel and save the time. With expensive carbon steels, however the case is reversed.

The handle on a shear should always be stored in the upright position to avoid injury caused by its protruding out into the workspace.

Cutting Using a Throatless Shear

Grasp the piece in the left hand (shears are only made in one direction; there is no left-handed version). Wear a heavy glove, as the cut metal is extremely sharp.

Open the shear completely and wedge the metal as far in as possible. For straight cuts, simply pull the lever to make a cut. Make a broad but careful slice, being careful not to use the very tip of the blade, as this will add a crimp to the metal. The shearing motion is a combination of feed by the left hand and pulling the handle with the right. Simultaneous movement is coordinated for smooth cuts that are either straight or curved.

To cut a turn, try to position the work such that the turn goes to the operator's right, as this plays into the shear's curved baseplate. Turns should also be cut as deeply in the shear as possible to maximize its leverage.

If you are having trouble cutting a difficult piece, err to the side of leaving extra metal rather than snipping off an important corner. Extra metal can almost always be cut or sanded off at a later date, but it is more difficult to add metal to a piece that has been cut short.

For very tight turns, the piece can be cut a short distance, reset into the back of the shear, and cut again. Some force may be required for extremely tight turns, so use care to protect the left hand against slivers and sharp edges as you press the piece into the turn.

Cutting Using a Jigsaw

For those who are not fortunate enough to have access to a throatless shear, a jigsaw is the usual alternative. Cuts with a heavy-duty jigsaw are much slower than are those done with the throatless shear, but they are possible even with a light-duty home workshop jigsaw.

Make sure that the jigsaw has a sheet metal blade and that the blade is secure in the saw. Clamp the work to a heavy bench or other solid surface, as the cutting action will cause a good deal of noise and vibration. Working slowly, begin the cut to the outside of the line. Be aware that the saw will remove slightly more metal than the width of the blade, so take this into account.

Flattening

When cut from the shear, the metal tends to twist slightly, so it must be flattened before deburring can begin. This is usually accomplished with a heavy rawhide or wooden hammer on the anvil face or around a bichorn, depending upon what kind of twisting occurred (see fig. 15.13).

DEBURRING

After the piece has been untwisted (this will not happen if it is cut with a saw), it must

Figure 14.3. This 18 gauge material was cut with blades that were too far apart. Notice the sharp lip that will now have to be removed with sanding or filing.

Figure 14.4. Cuts from the shear or saw will often be less than perfect. One of the objectives of deburring is to smooth out the waves and bring the piece in line with the pattern while removing dangerous burrs.

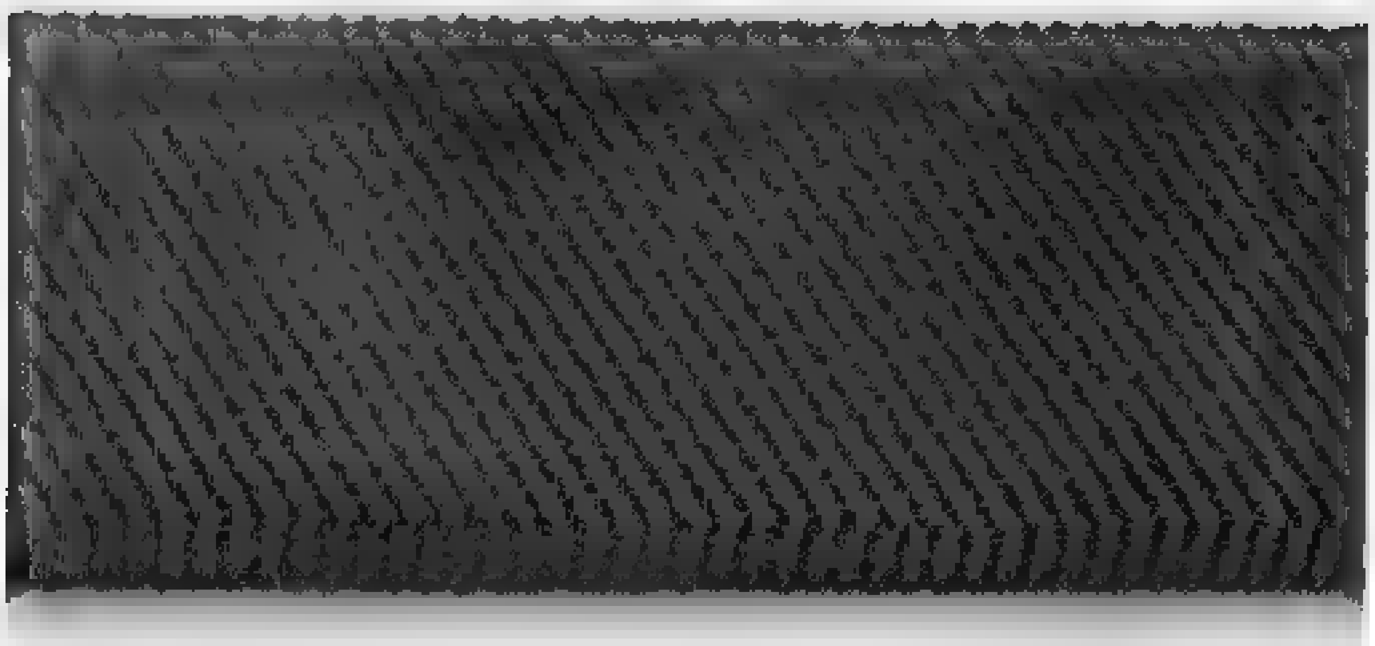


Figure 14.5. Filing done by hand can be done with a fine mill file if the quality of the cut is good. Any filing should only be done in a forward direction since the file's teeth are bent back when the tool is moved in reverse

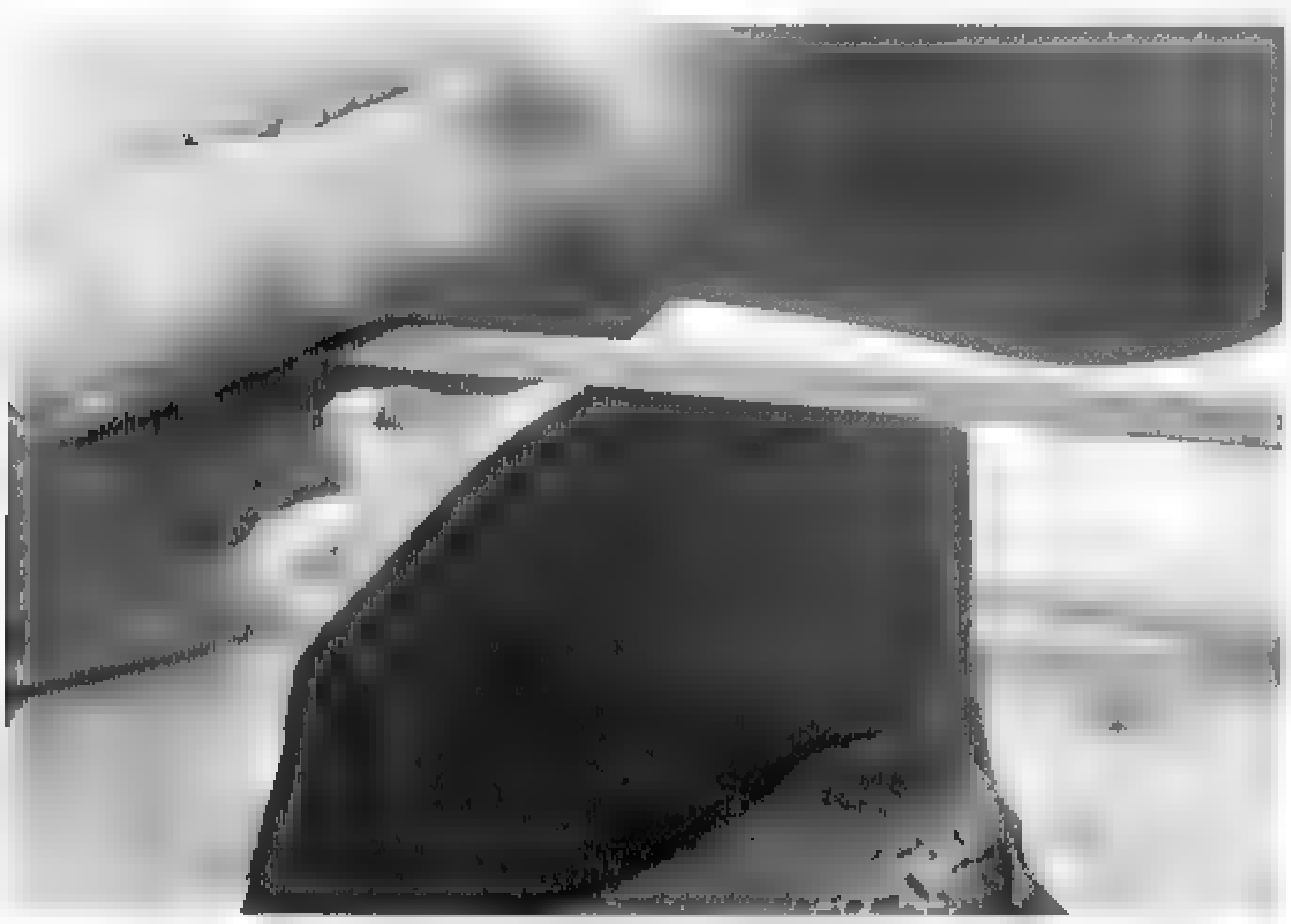


Figure 14.6. When deburring with a file, the work should be clamped securely into a vice. Successive passes are made with the file kept perpendicular to the face. Hold the file gently but firmly, making a pass along the edge of the piece, maintaining a 90° angle for the duration of the pass. Once complete, a quick pass is made at 35° over each edge per Figure 14.7

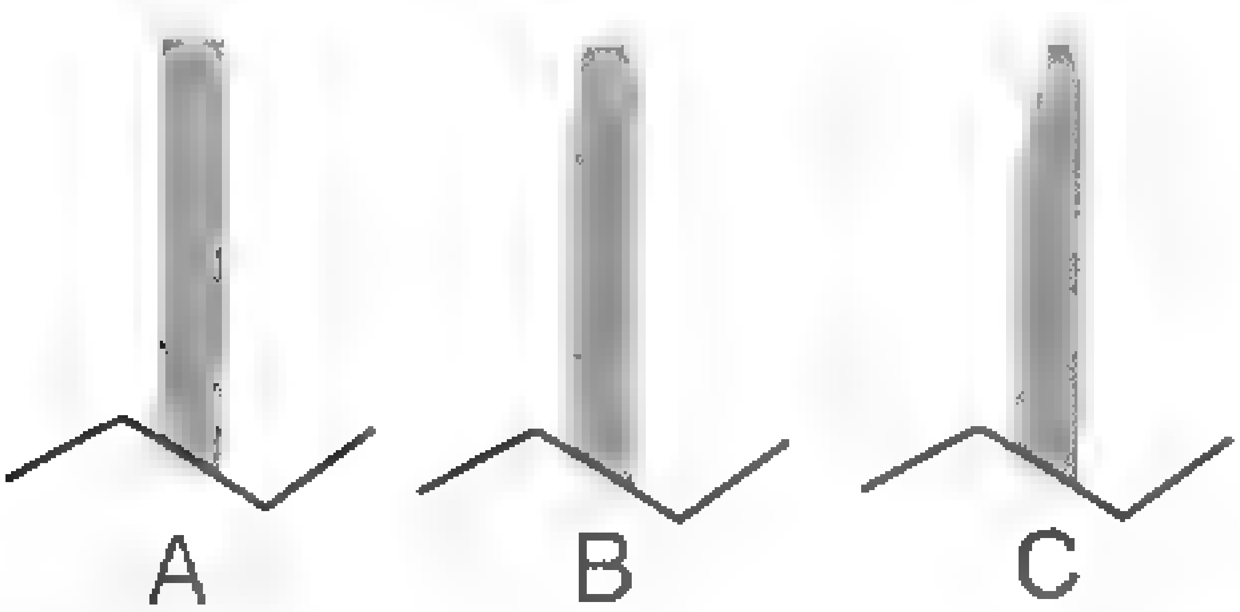


Figure 14.7 The first step in deburring the edge is to work at 90° and then do a quick pass over each corner at a 35° angle to remove the edge's sharpness A The edge first sanded to 90°. B. The edge quickly filed or sanded to 35° C A common sanding error, where too much metal is removed from the plate's surface.

Figure 14.8 Files with curved faces are used to work on concave surfaces Convex surfaces can easily be done with the flat edge

Figure 14.9. Using a sander or a sanding disk on a buffing motor will greatly speed the deburring process but it is no replacement for the ability and care that can be exercised with a file A sander cannot reach everywhere that a file can so the armourer using a sander should consider if it is truly the best tool for the job

be deburred before it is worked on to remove sharp spurs and nicks that will crack and splinter during forming. These sharp edges can cause severe lacerations to the hand if not removed. Another objective of the deburring process is to even out the cut from warble caused by unsteady cuts and to bring the piece into conformity with the pattern.

Deburring can be done either in the traditional way—by hand with a file—or on a fine sanding disk or belt. Both will return excellent results, and both are correct in medieval terms, as armourers had access to both files and wheels of various sizes to grind the armour's face and edges. Mechanical sanding is faster, slightly less safe, and requires a better touch to keep the piece's lines smooth. Hand filing returns a more even finish, but it is a much slower process.

However you intend to smooth the edges, remember that you are trying to do so by knocking down the rough spots caused by forming or cutting. It is easy to get carried away, especially on a sander, and create a knife edge rather than a smoothed edge (fig. 14.7c).

Selecting a File

If the cutting work is good, then a fine "mill" file can often be used to file the edges (fig. 14.5). More often, a medium or coarse "bastard" file will be required. Because file teeth cut only in one direction and are weak in the other, strokes should be made only in one direction, away from the armourer and the file's tang. Strokes should be bold and smooth, using as much of the file's surface as possible to extend the life of the tool (fig. 14.6). When a file wears out, it cuts poorly if at all—but don't throw them out because they can be recast into excellent tools and are sometimes even forged into fine-quality knives.

Deburring with a Sander

Using a sander for deburring greatly speeds the process, but care must be taken not to take too much metal away. Sand to the inside of the pattern line, and do not press the metal so that it discolors. Remember that sanded edges will be extremely hot and can cause burns. Gloves and eye protection should always be worn.

The process is the same is when done with a file—the piece is first evened out at 90 degrees and then very quickly moved along at 35 degrees to remove the resulting microedges. The piece can then be held up to the light—a smooth band of light that flows smoothly along the edge indicates that the deburring has been done well.

When the deburring is complete, the edge will feel smooth to the touch, without bumps or ripples. (Make sure the metal has cooled and the burrs have been removed before trying this!) When this is the case, the piece is ready for rudimentary forming with the hammer.

Figure 15.1 A planishing hammer poised over a working surface. Light as a tool is as important as the hammer and stake: medieval illustrations always depict the armourers working next to a window. Using light the modern armourer can detect flaws and ripples, adjusting the work accordingly.

Chapter 15

Basic Hammerwork

Whether the work is munitions grade, a masterpiece, or anything in between, an armourer's work with the hammer is the foundation upon which the final quality of the piece rests. The primary quality for good hammerwork is "evenness," the armourer's ability to lay hammer strokes one after the other in close proximity with equal force. If this can be developed, then he will have great freedom to create the desired shape.

Hammerwork consists of both "rough" and "finish" forming phases, after which it is ground and polished. Poor hammerwork usually can not be salvaged through finish technique, though it can sometimes be hidden by excessive grinding or fabric coverings. This is not always bad, as it allows otherwise mediocre pieces to see good service.

A piece is rough-formed using curling, doming, flaring, and raising techniques. Next it is refined by bouging, which eliminates the worst of the remaining high and low areas. Finish techniques include forming enhancements such as rolled edges, creases, and embossings. A final hammer pass over the entire piece —called planishing hardens the metal, eliminates any remaining imperfections and minor high or low spots, and completes the hammerwork phase.

WIELDING THE HAMMER

An armourer's skill with the hammer depends on his mastery of rough and finish forming technique. The hints that follow should assist the armourer to develop these skills, but they cannot be mastered without time and experience. Patience is perhaps the armourer's most important ally, for a hurried effort will yield many small mistakes. These mistakes add up to build a decided "fuzziness" in the final product, something that cannot be covered by a high-gloss finish or extra brasswork.

A piece should appear well-made at all stages of its production. Excessive lumpiness, twisting, or other malformations indicate inexperience or a rushed execution. Often these rushed pieces cannot be salvaged through final hammerwork or polishing. Patience during hammerwork will yield rich rewards in symmetry, heat-treating, and finishing.

Hammer Faces Should Be Polished

In all but the roughest work, a highly polished hammer face is important (fig. 15.2). Since the hammer blow will trap the metal between the hammer and forming tool, any imperfections on the face will be transmitted directly to the work. Since the hammer is generally striking the surface that will be the exterior of the finished piece, any small scratch or nick makes the finishing work harder.

Grasp the Hammer from the End of the Handle

A hammer functions based on the power transmitted from the hammerhead, which is suspended at the end of a lever arm (the handle). The armourer should use the longest available handle, gripping it as far from the head as possible while still retaining precise control over the placement of each blow (fig. 15.3). Many novices make the error of grasping the hammer too close to the head. This defeats the power of the lever arm of the handle and reduces the force of each blow (fig. 15.4).

Generally speaking, the elbow rather than the wrist is the proper pivot point. The shoulder, upper arm, and wrist remain more or

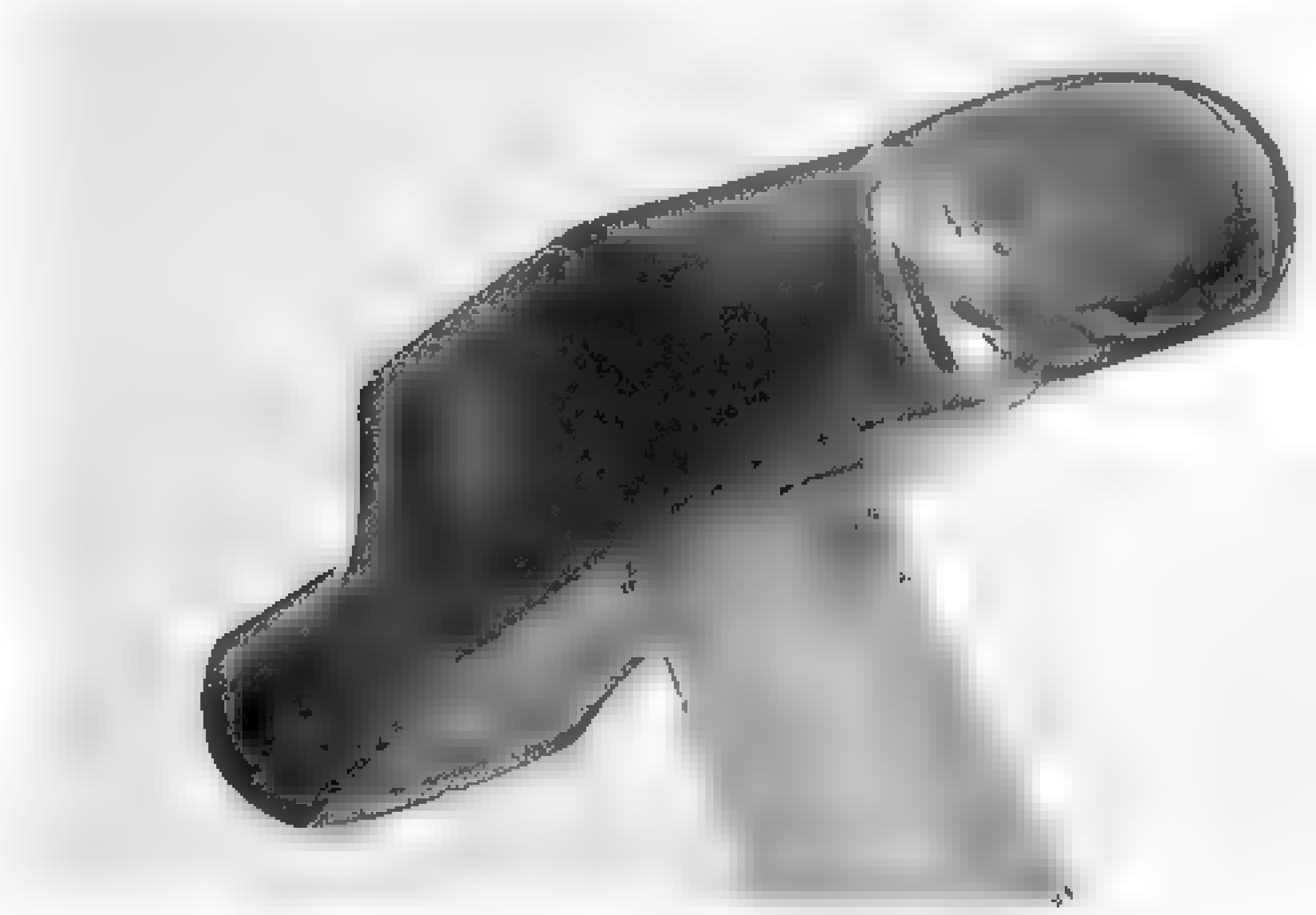


Figure 15.2. Because the hammer face transmits its surface directly to the work surface, it should be as polished as possible Nicks in the face will transmit to the work and will complicate planishing, grinding, and polishing

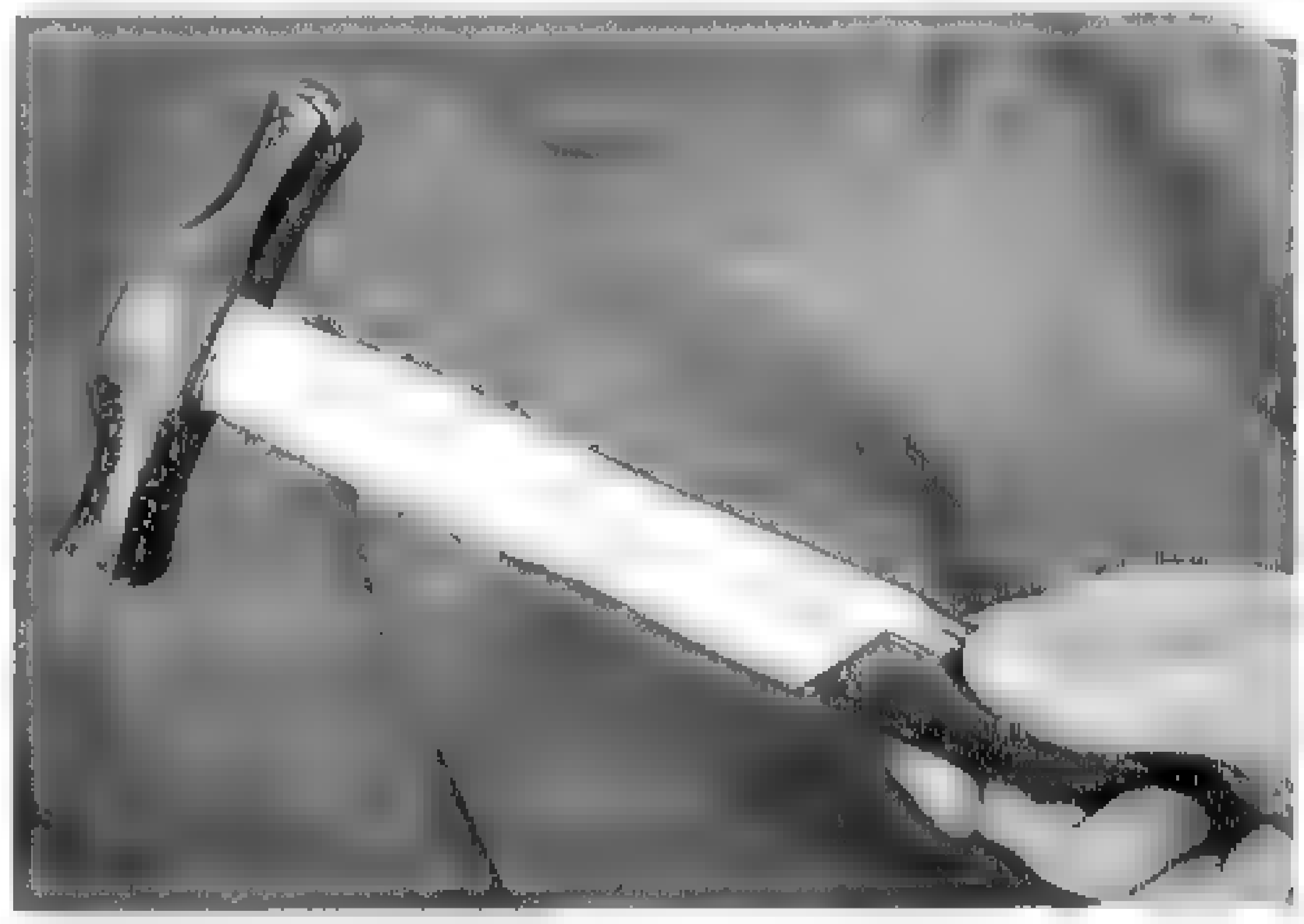


Figure 15.3. Grip the hammer handle near the end to achieve optimal leverage

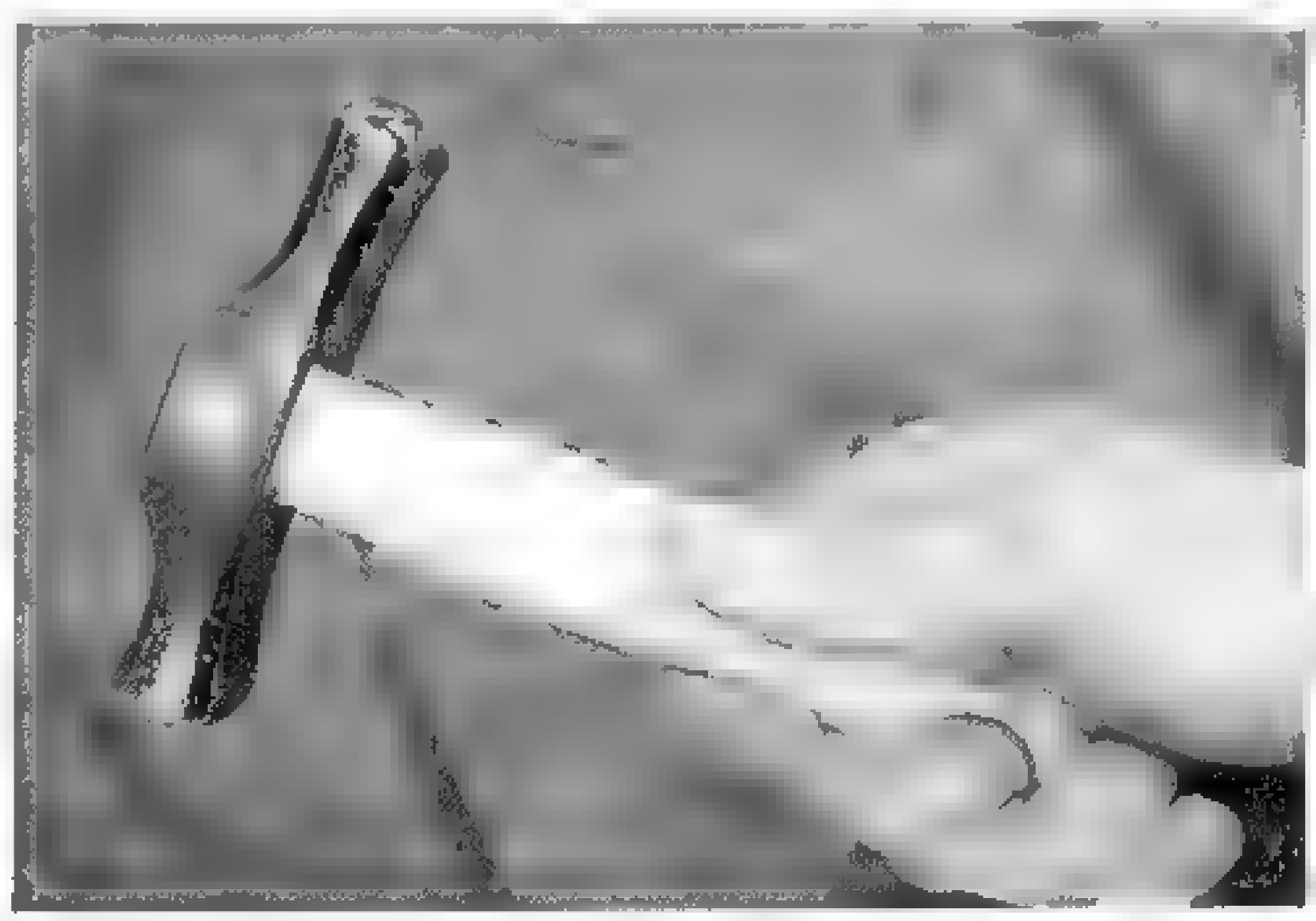


Figure 15.4. Do not grip the hammer close to the head because it is very energy inefficient

less stationary; the elbow is the only joint that should be moving.

Position the Elbow Close to the Body

The elbow should be kept close to the body and the hammer blow thrown using the whole arm from the elbow to the hammer-head (fig. 15.5). Do not attempt to make blows with the wrist unless absolutely required. In this way the most important element of good hammerwork can be achieved by limiting the number of muscles involved and making a stable, predictable platform from which to work. When I am doing fine work or that which requires great precision, as in the laying of an important crease, I often want the work closer to my eyes. Even then the arm should be close to the body. Additionally, this position is ergonomically superior, since it does not place undue stress on the elbow tendons.

Position the Work at an Easy Height

Place the work at a comfortable height, preferably so the hammer face will strike the work just above the waist. Stake plates, vices, dishing stumps, anvils, and the like should be placed at this height.

Move the Work, Not the Hammer

In any hammering, the piece should be moved, not the hammer. Maintain precisely the same motion and the same position of the hammer and stake, moving the piece between them. Think of it as a machine through which you move the metal. This is an extremely important component of the armourer's art, yielding a large part of the needed consistency.

Use Light to Keep a Close Eye on the Work

If you position yourself properly relative to the available light, you will be able to use the metal's reflective qualities to monitor your progress (fig. 15.7). If you are using a highly polished hammer, then even rough hammer-work will shine the metal to some degree, making it easy to see what is happening to the work surface.

Deliver Even Hammer Strokes

The force of each blow should be approximately equal. There will certainly be times when very gentle strokes or extra force are appropriate, but 90 percent of the work should use a "standard" hammer blow.

Work in Courses

Hammer blows are applied to the work in courses, rows of evenly struck strokes that form "lines of work." As we shall see in later chapters, courses may be applied in a variety of patterns to achieve different goals, but generally they are laid either in spirals or lines.

Figure 15.5. Keep the elbow close to the body to reduce torque on the elbow's tendon. Better hammer control is also achieved.

Figure 15.6. Avoid the "flying elbow" problem, which yields poor control and can cause damage to tendons.

Spirals are used to dome metal or to raise it over a forming stake. The course is begun from the inside of the piece, spiraling toward the outer edge. Lines are used to flare a piece or to "backraise" or sink a section to modify its lines in terms of dome.

Envision the Brick Wall

Think of your workpiece as a wall of brick or stone. The object is to produce a pattern that resembles bricks in a wall (for fine or finish work; figs. 15.8–15.9) or fieldstones in mortar (for rough work). In either case, the idea is to achieve an even set of courses.

Although the hammer marks will not normally be seen in the final work, the courses should be even for two reasons. First, it hardens the metal evenly across the area being worked, resulting in a stronger piece that is less likely to malform under the stress of combat, in heat-treating, or in later stages of the forming process. Second, it is far easier to control the final symmetry and form of the piece if the hammerwork is even. The regular nature of good hammerwork drastically shortens the time to finish it with planishing (finish hammerwork), sanding or filing, and polishing. Should the rough or finish hammerwork prove too uneven, the work will not be able to be finished satisfactorily, as excessive sanding will highlight uncorrected errors if they are too large.

Space Blows Evenly for Rough Work

At the early stages of a work, when rapid rough-forming is desired, place the blows as evenly spaced as possible. This will keep the piece from excessive malforming by keeping the hammer's stress even across the section being formed.

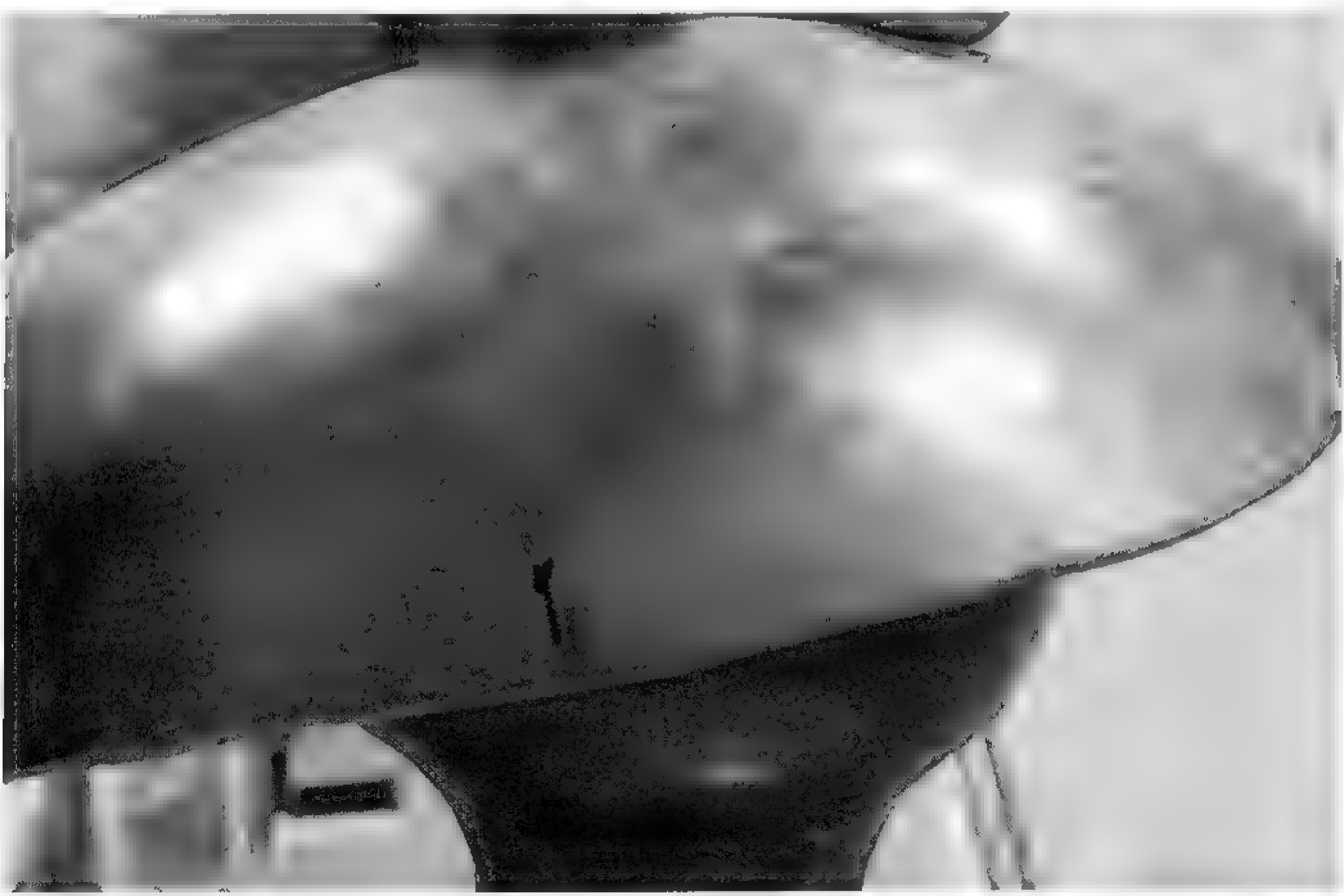


Figure 15.7. Light is one of the armourer's key tools. Position yourself so that the light reflects from the surface upon which you are working, particularly in planishing phases. Where the line of light breaks the metal is still uneven.

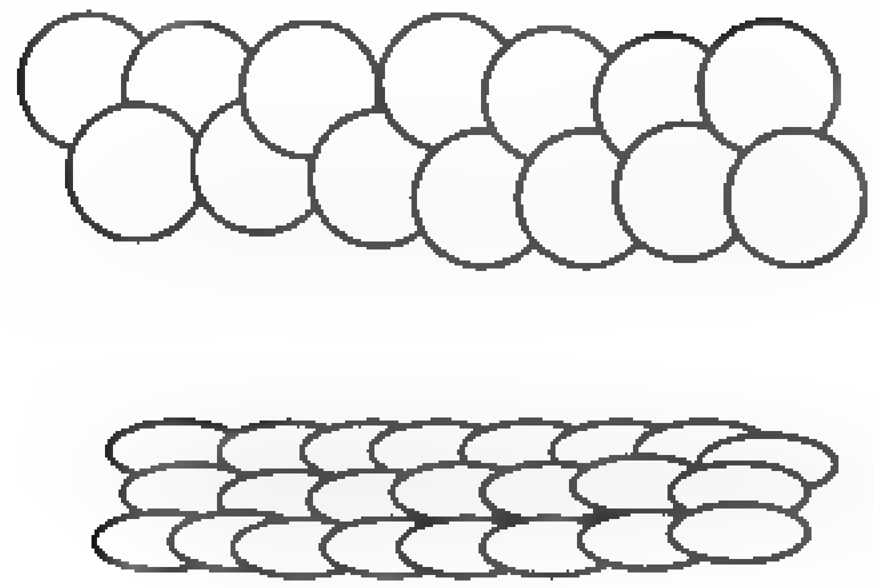


Figure 15.8. Good hammerwork is dependent upon control of the hammer. Individual hammer strokes should overlap slightly and be done in even strokes, forming a result not unlike a brick wall.

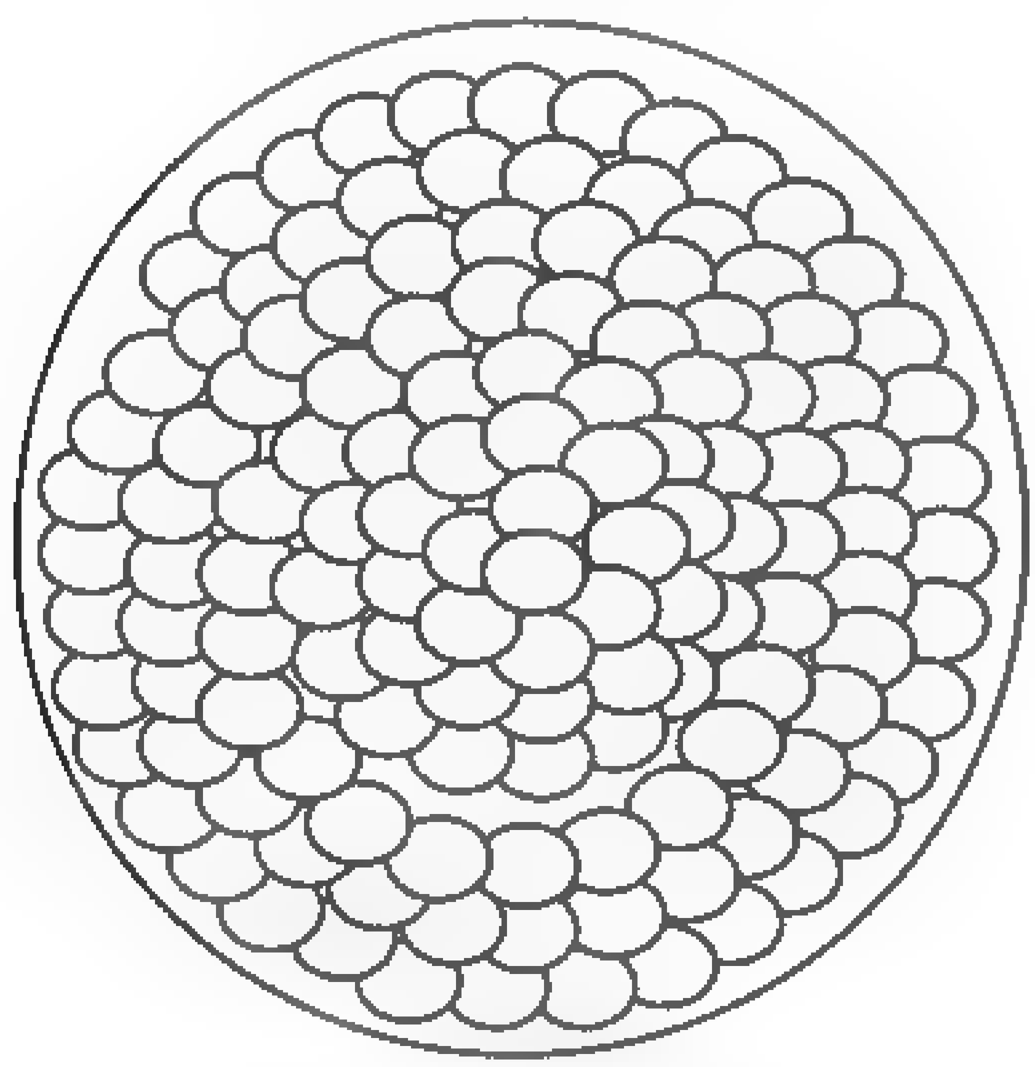


Figure 15.9. Doming and raising should be done in spiral courses. Domed pieces (worked from the inside) start from the outer edge and work inward, while raising (working from the outside) starts from the center and works outward

Overlap Blows Slightly for the Best Work

For fine or finish work, hammer blows should not be spaced at all but rather should overlap one another by a small amount, both in terms of side-to-side and top-to-bottom.

PRACTICE PIECES IN COPPER

In order to build skill in laying hammerwork courses, I like to have my students work with two small copper plates. We use copper because its softness yields deep hammer marks, which clearly show the quality of the technique.

In the first piece, the goal is to produce a solid sheet of copper that has even courses laid upon it from top to bottom in the manner of a brick wall (as in fig. 15.10). Courses are laid from top to bottom or from bottom to top, the idea being to produce a piece that is pleasantly decorated with an even brick wall effect.

First cut a piece of copper 3 x 5 inches, flatten it, and debur the edges. A smooth-faced raising hammer is preferable here, but any rectangular-shaped hammer can be used. Work on a smooth surface such as an anvil face. Position the work at the proper height, keeping the elbow tucked in. Begin the course from near the top of one edge, progressing across the piece evenly from side to side. Move the work slightly to overlap the blows approximately 1/4 to 1/3 of the distance of a hammer face. Continue to the other edge of the piece, holding the work flat on the anvil to avoid curling.

Figure 15.10. Flat work in copper

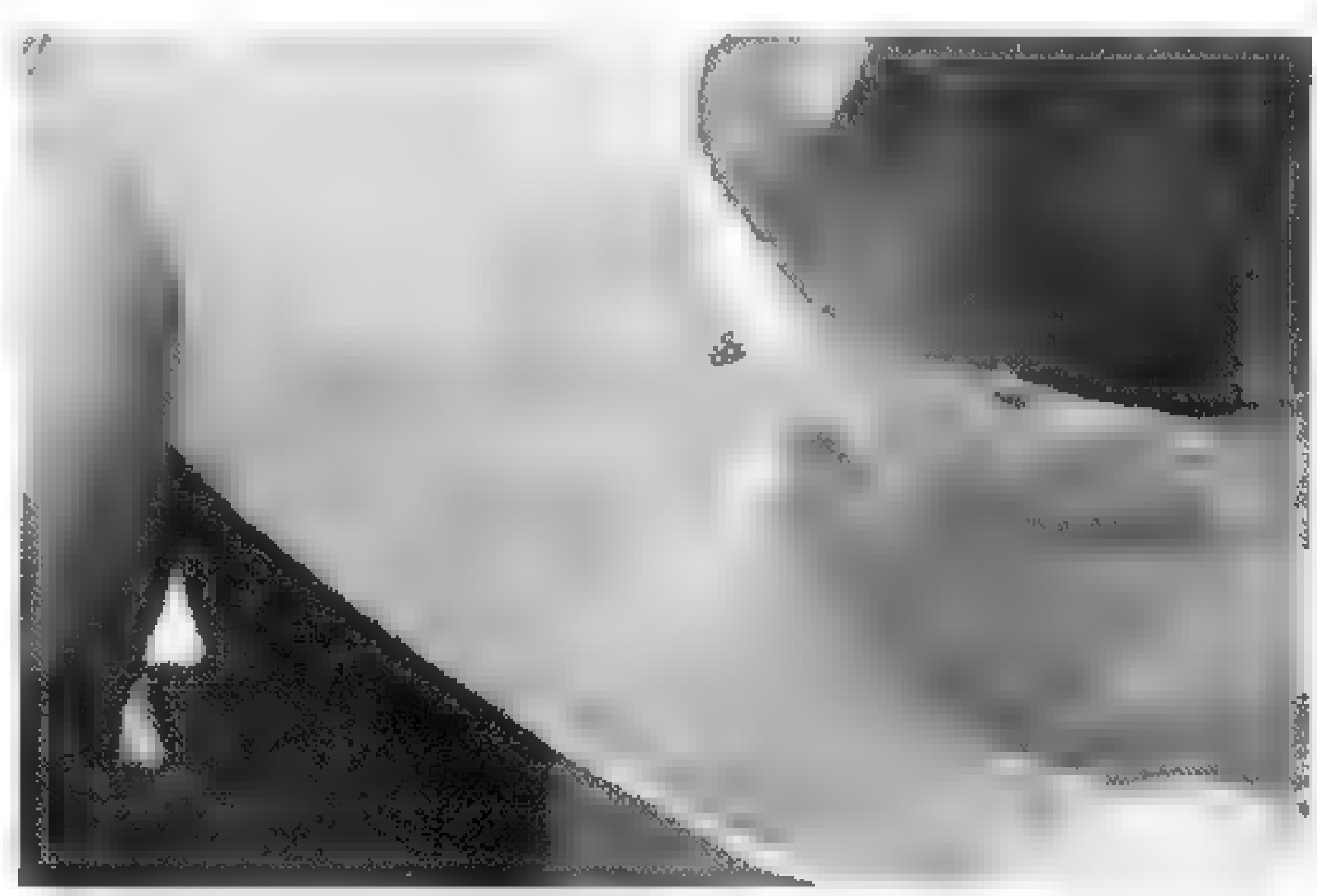


Figure 15.11. Doming work in copper

The result should be something like the example in Figure 15.10. If the piece is not held flat it will start to curl, which is useful in forming cuisses, lames, and the like, but is not the point of the exercise.

With the second example, the object is to practice rougher forming and doming on a flat surface, a skill that was probably common in the Middle Ages (see especially fig. 5.1, where the armourers appear to be doming or bouging a breastplate on a flat anvil face). This is very useful for cuirasses, lames, and shaped cuisses and for all pieces that need slight doming. Also, no special dish is required, and the results do not generally require much planishing.

Cut a circle of copper or steel, approximately 4 inches in diameter, and debur the edges. Next, use a rawhide hammer or piece of wood and a large mallet to flatten the stock. Select a domed planishing or doming hammer (even a slightly domed ball-pien will work), working on a smooth, flat face such as an anvil or section of railroad rail. Position the work at the proper height, keeping the elbow tucked in. Using a permanent marker, mark the center and draw a tight spiral (about 1/2 inch between lines) toward the outer edge. Begin hammering in the center, holding the piece up and striking at the point just above where it makes contact with the anvil's surface. Follow the spiral outward, spacing the blows evenly and maintaining a consistent angle. Repeat as necessary, striving to make the resulting "bowl" as regular as possible. Use the reflection from the available light as a guide to keep the work even.

Using this technique, even moderately deep bowls can be done without resorting to a dish, although the metal is thinned significantly as you go deeper.

BASIC ROUGHING AND FORMING TECHNIQUES

All hammerwork should be done smoothly in passes, even in the rough forming stages. The following sections will give the armourer a survey of the techniques needed for most armour of the transition, skills that form the basis of all future work

Flattening a Piece of Steel Using a Rawhide

When a piece of metal is cut using a shear, it tends to curl. This curl should usually be removed prior to any filing or hammerwork, since it can catch on sanding surfaces and cause injury. The pieces can also twist, especially narrow pieces that are cut from a larger sheet.

The first problem is to learn what to look for. In some cases the edge itself should be struck, while in others the highest point on the curve should be struck instead. In many cases a combination of both is required. Rawhide hammers are often used for this task, as they leave no hammer marks that have to be removed later and they don't harden the metal as quickly.

Edge Curl

When only a single edge requires attention it can usually be repaired by simply striking the edge of the curl itself. Hold the piece just off the edge of a solid surface—preferably metal—and use a light rawhide hammer to tap the offending area back into position. Sometimes it will be necessary to flip the piece over and work several edges to remove all the curl. Practice getting pieces exactly flat, setting up a good start that will teach you how metal moves.

Twisting

When a piece of steel becomes twisted in the cutting process or during forming, it can

Figure 15 12. Removing the curl on an anvil

be quickly returned to flat by striking it several times at the apex of the twisted section (fig. 15.13).

Curling

Although the best examples of the armourer's craft do not have any purely flat plates, the exigencies of production- or munitions-grade work often require quick curling of flat sheets. Such sheets are used on helmet skirts, brigandine plates, lames on arm or leg harnesses, gauntlet cuffs, simple gutter vambraces, and cuisses. Because the human shin is a curvaceous section of the body, simple gutter defenses for the lower leg should never be used; these ill-fitting components are uncomfortable and destroy the elegance of the human leg.

Curling Lames

Usually it is preferable to curl lames using a wooden or rawhide mallet to avoid unnecessary scoring of the metal. The fast way to curl lames is from the outside over a horn or bichorn, though even a section of railroad rail will suffice (fig. 15.14). For lighter gauge metals, small, light strokes can be placed near the edge of the piece to be curled. The leverage formed causes the metal to curl slightly at the horn rather than where the hammer strikes. Slowly and smoothly feed the piece from one side to the other and you should end up with a fine, straight, and even curl. Uneven force from the hammer or an uneven feed rate will result in an uneven curl.

If the hammer is struck from the edge or if the piece is not parallel with the horn, then you will not get a cylinder but a cone. This can be problematic when forming lames, and the eye must be refined to detect and correct these errors or the resulting fit of plate on plate will be difficult.

Curling Gutteral Plates (Vambraces, Rerebraces, Cuisses, Helmet Skirts)

Curling a cuisse or other gutteral piece from the outside is not significantly different than the process used for the lame, except that a heavier hammer is required. The difference in technique is that the hammer must be moved along the whole edge to convince the metal to curl around the horn (fig. 15.15). The problem of unintentionally creating an odd cone instead of a smooth, even, gutter shape is more acute, but for vambraces and helmet skirts, something of a planned conical shape can be accomplished.

Long plates like this can usually be roughed over a horn, then cleaned up by further curling from the inside using a slightly domed-faced hammer.

In an inside curl, the metal is held just off of the flat surface, the lower edge propped against the surface and the left hand holding the back end up just a bit (fig. 15.16). Hammering will force the metal against the

Figure 15.13 A twist can be removed by striking the apex of the curve.

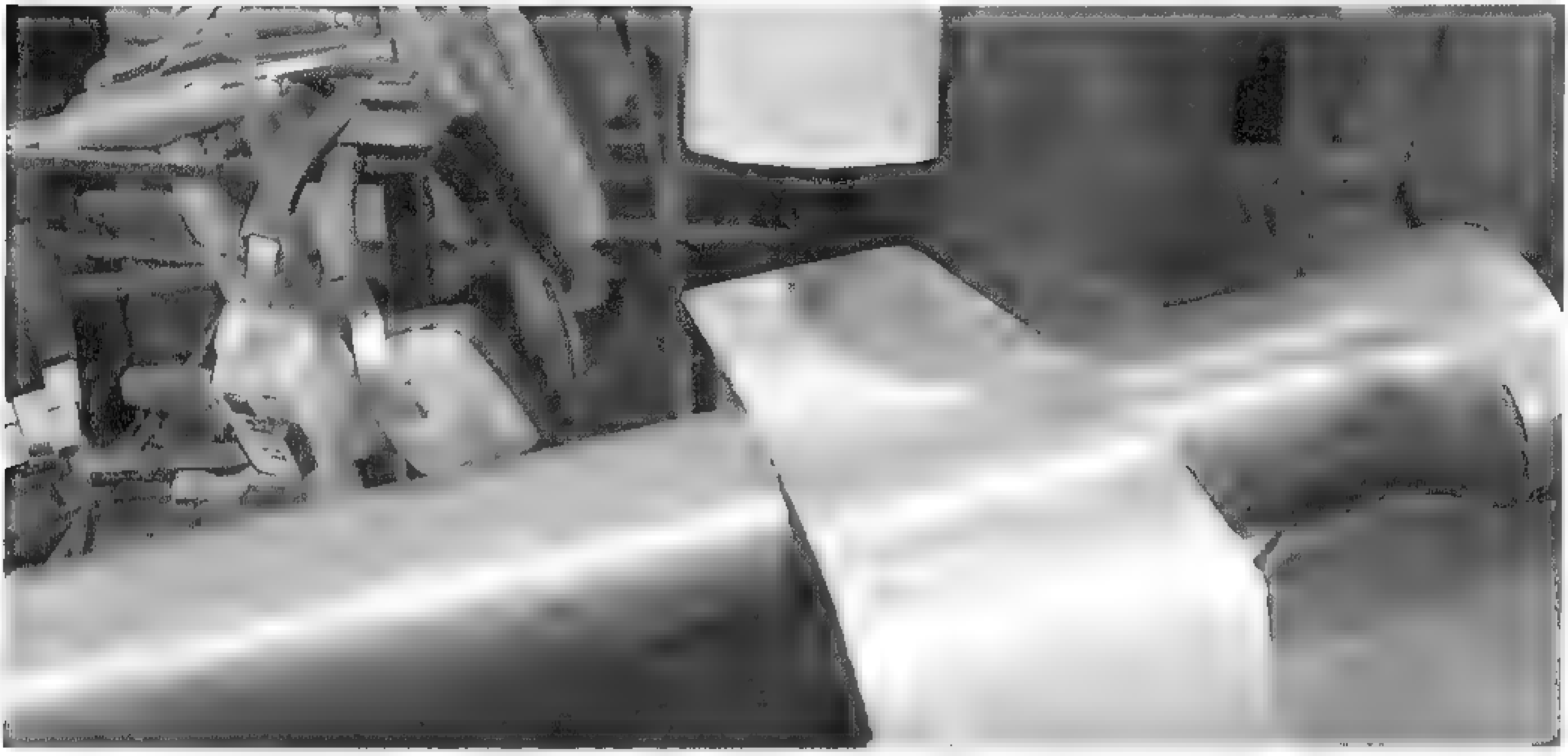


Figure 15.14. Curling a lame

anvil and cause it to curl. The hammer must be moved evenly from one side to the other before the piece is fed. Long straight rows of hammer marks should result (fig. 15.17). The leg harness pictured is taken from the project in Chapter 34.

When applied to something like a cuisse, the hammer marks add hammer-hardening, which helps the piece to resist deformation. If done well, no further planishing on the outside is required.

Such work done from the inside is consistent with the many shallowly domed hammers from the Medieval period. I believe that medieval armourers frequently worked from the inside, roughing their pieces and then grinding the surface to conformity. Recall that the iron or steel sheet with which they were working was far less regular than our modern equivalents.

Doming

Since few pieces of fitted armour are ever formed of simple curls, most require some measure of dome or flare to achieve the required line. Doming (or "dishing") refers to metalwork done from the inside of the armour piece. Striking it from the inside against either a hard or soft form, the metal is stretched into shape.

Figure 15.15. Curling a heavier "gutter" shaped piece

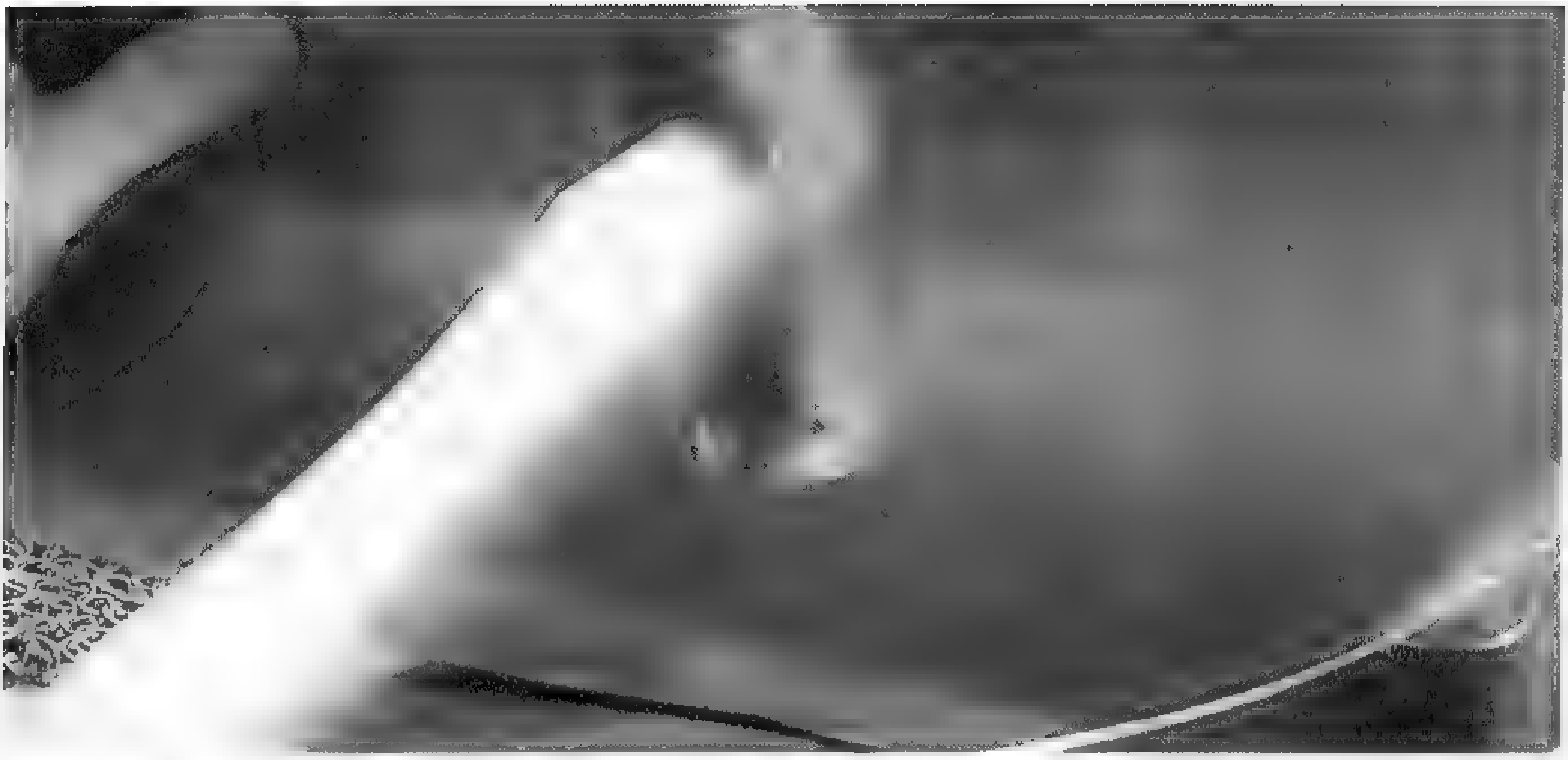


Figure 15.16 Curling a cuisse from the inside

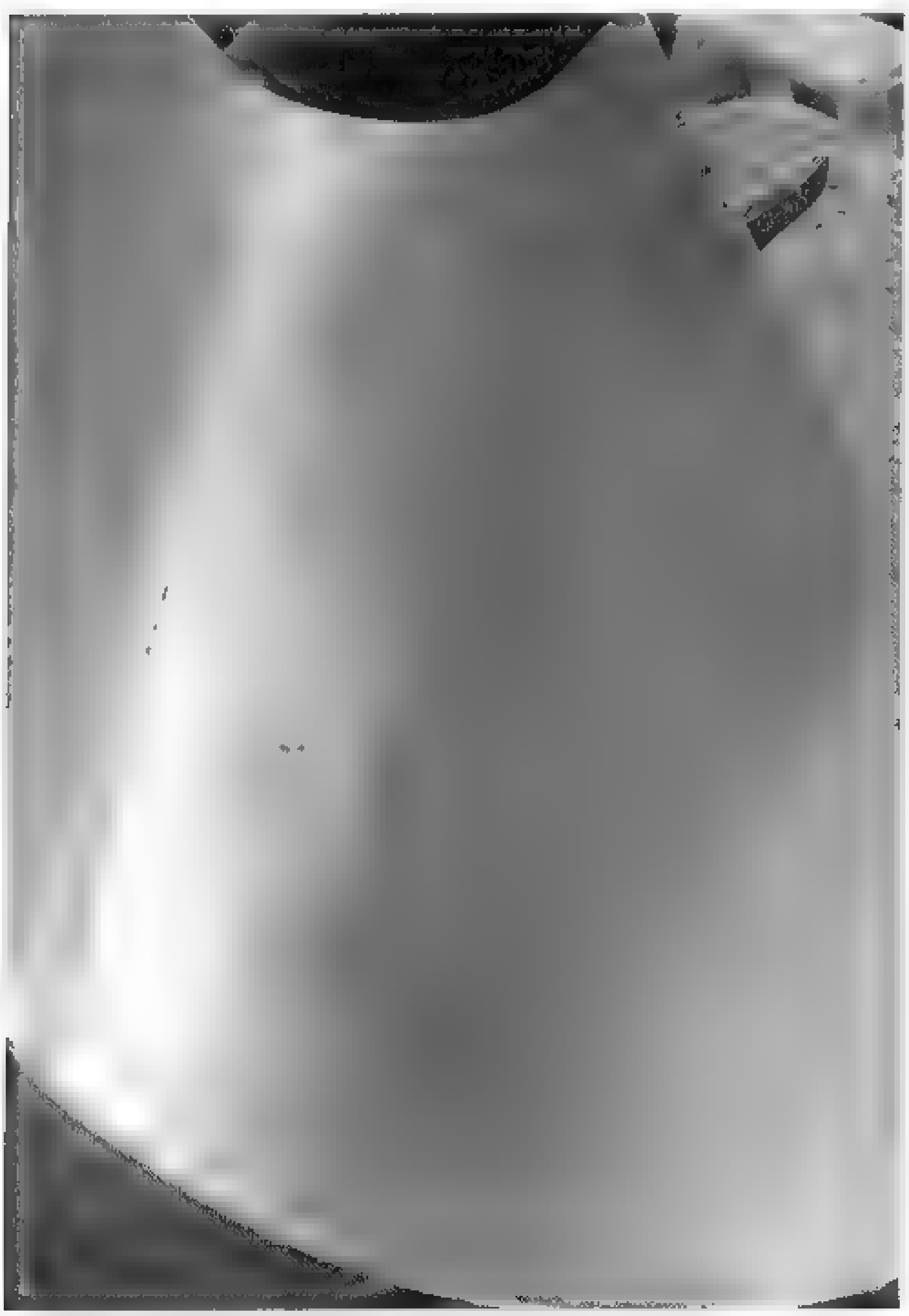


Figure 15.17 Hammer marks on the interior of a well-curled cuisse

Within reenactment communities, dishing is the most common forming technique after simple curling. The bulk of reenactment armourers use only these two bodies of technique because they are relatively easy to learn and are fast to execute.

While doming is easy to learn, it has important disadvantages. The act of stretching the metal by definition thins it. While this does not present a great difficulty when forming pieces for simple decoration, for the reenactor it has profound impact, particularly in helmets, poleyns, and couters. Helmets that start as 14 gauge can easily become 16 gauge if deeply domed and sanded. Poleyns and couters, requiring even deeper doming, can stretch to extreme thinness, rendering the formed pieces useless for anything but display, as they will crush under light impact.

For these reasons, most domed components must start off with a heavier gauge of metal (this is taken into account on the earlier tables provided) or be welded in pieces to reduce the amount of stretching necessary These pieced components are usually quick to produce but may be weak should the welds not be of the highest quality.

Doming with a rawhide hammer tends to stretch the metal less than similar work

conducted with a steel hammer. Because of their larger, semisoft faces, the forming work done with rawhides is also reasonably even, and less bouging is required. Worked into a steel dish, no rough-smoothing at all is required, and should the dish match the necessary dome, even final planishing can sometimes be avoided over the whole surface. This is especially useful when making cuirasses and breastplates, since the volume of surface area makes even bouging and planishing a daunting task.

The ease with which a piece can be domed depends on two things. First is the thickness of the metal involved. Thinner steel is easier to dish than is thicker, but it tends to malform more quickly. Second, the degree of match between the doming die and the final shape will determine how much judgment an armourer must use. The ideal case is to have a steel form into which the work can be stretched completely until it makes contact with the die. When all points are in contact with the dish, the doming operation is complete.

Ideally dishes are polished, but I tend to leave mine lightly scored because they already match the desired doming depth exactly. This creates an interesting pattern that a novice can use to ascertain when the doming operation is complete—when the area being worked is covered entirely by the pattern, he knows he is done.

Shallow Domes

For shallow domes, it may well be possible to accomplish the required depth in a single pass (fig. 15.18). For deeper domes, such as those required on couters, poleyns, and helmet skulls, multiple-stage doming is recommended (fig. 15.20).

To dome a shallow piece such as a lame or the bronze Wisby spaulder pictured in Figure 15.18, simply work the pieces in a spiral from the edges to the center with a heavy rawhide mallet. This technique works well whether the dishing stake is a sandbag, stump, or steel dish. Steel dishes have the advantage of not requiring any planishing, while those done in a wooden dish or sandbag often need some cleanup.

If folds appear at the edges, they should be hammered flat immediately or they can quickly turn into creases and even tears. This is not so much of a problem on shallow pieces, but when deep stretching is attempted it can be critical.

Stretching like this can also be done with a broad, domed-faced steel hammer. The results will take a bit longer and require much more finishing, but there is an element of control

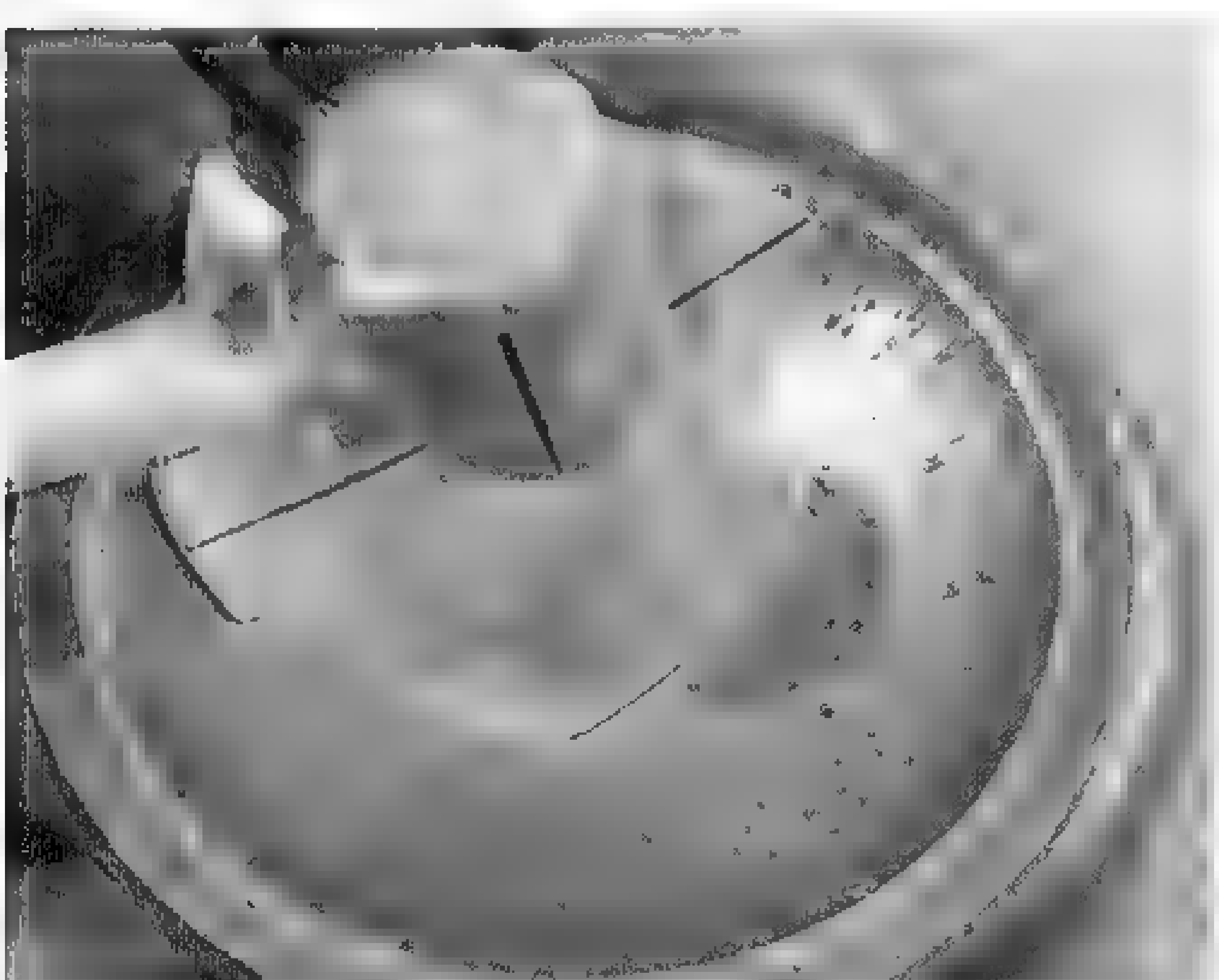


Figure 15.18. Doming a shallow piece into a dish

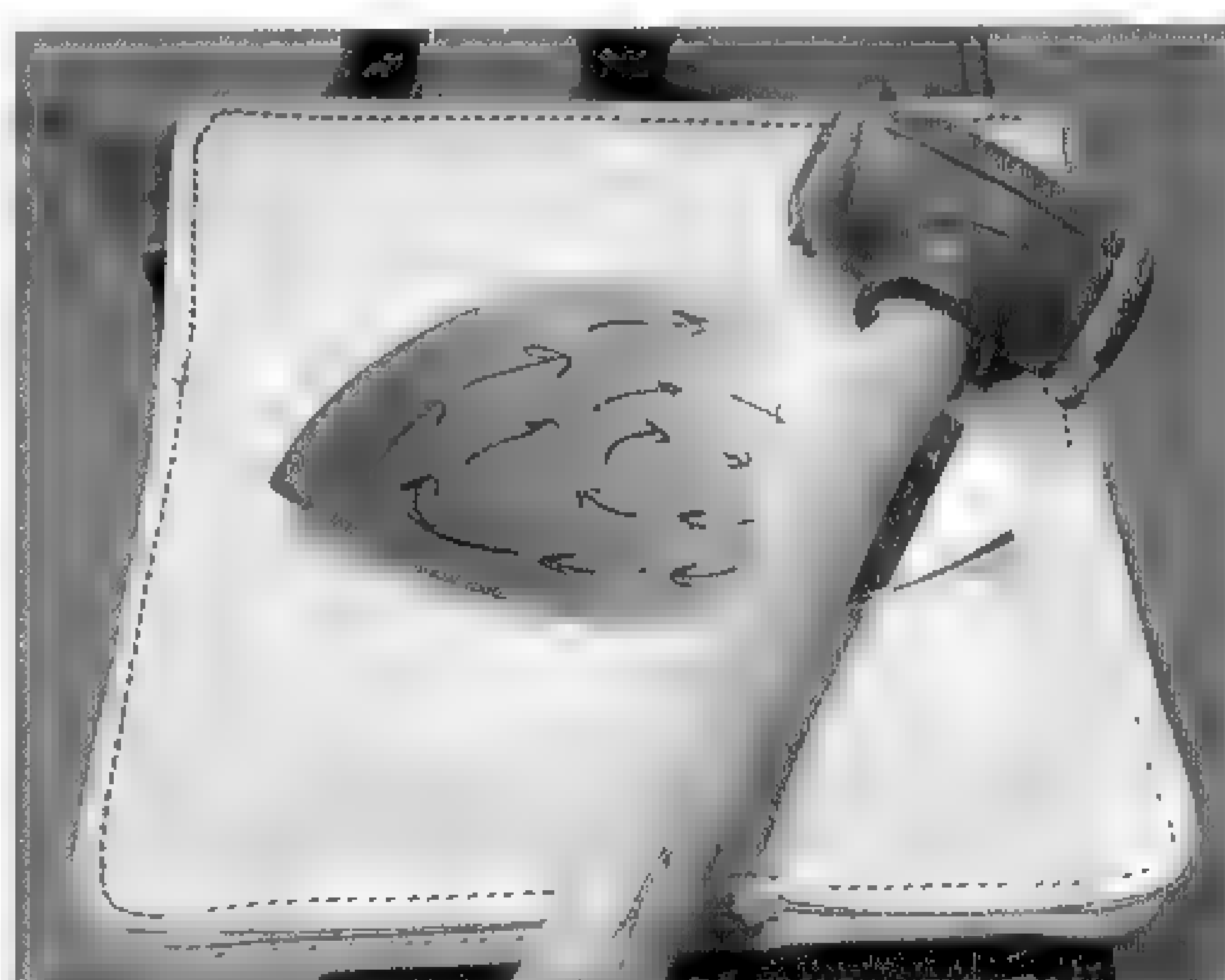


Figure 15.19. When doming into a sandbag, use care not to catch the edges of the metal against the material or it can rip. I have seen sandbags like these made out of both canvas and leather, although 7 to 8 ounce leather seems to work the best. Fill them with sand or #9 birdshot.

Figure 15 20. Dishes for staged doming

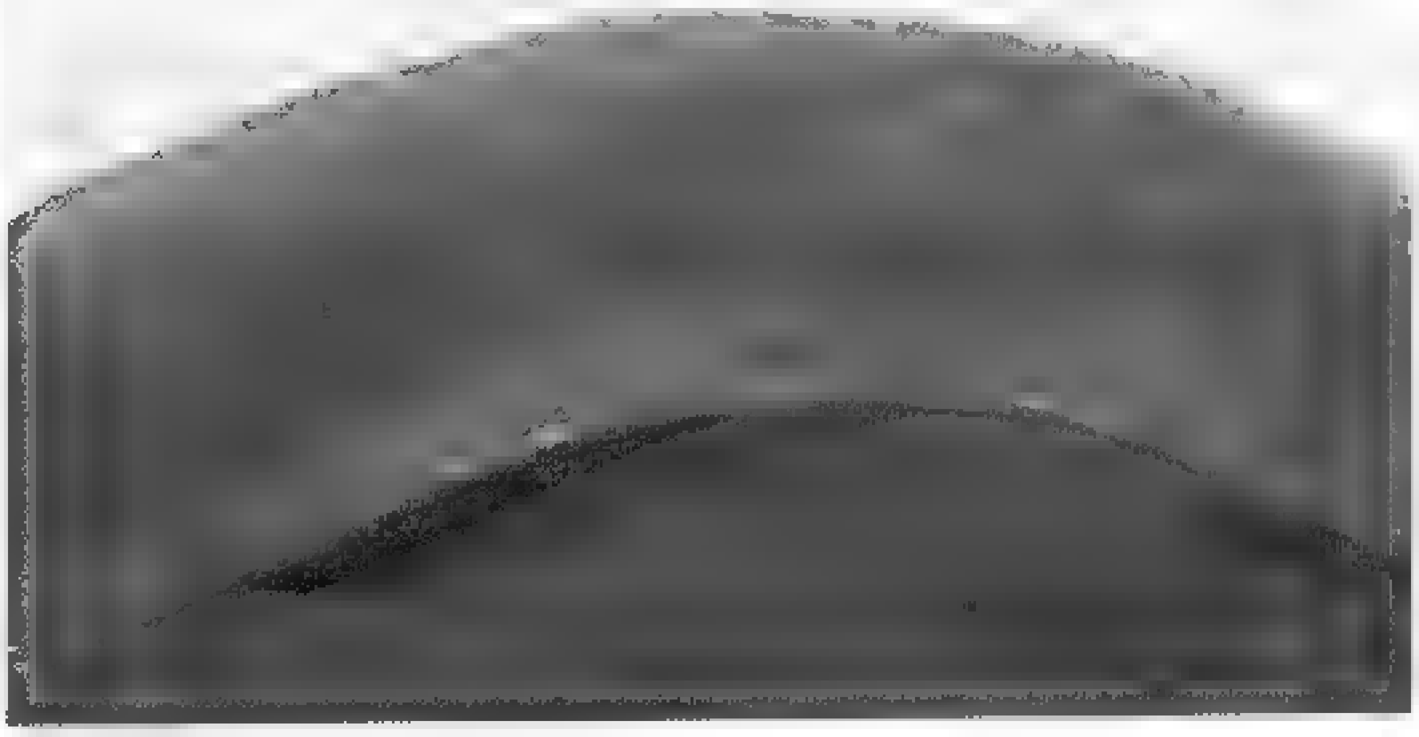
present when using a steel hammer that some armourers prefer (fig. 15.21).

The large, shallow dishing projects shown above will only account for part of the armourer's work; most projects, including helmet skulls, couters, poleyns, and spaulder cops, are more deeply domed. Each of these pieces would be best formed using the advanced raising techniques discussed in Chapter 18, but they can be domed using a multiple-dish process, providing that care is taken.

Deep Domes

For deep doming, start with a flat sheet and use a heavy rawhide or wooden mallet to dome it in a spiral pattern from the edge inward, working in a shallow dish (as in fig. 15.18) until the metal is roughly domed to the shape of the dish. This is done to start the process and make the deep doming easier, though a little care

Figure 15.21. Doming a couter into a deep dish



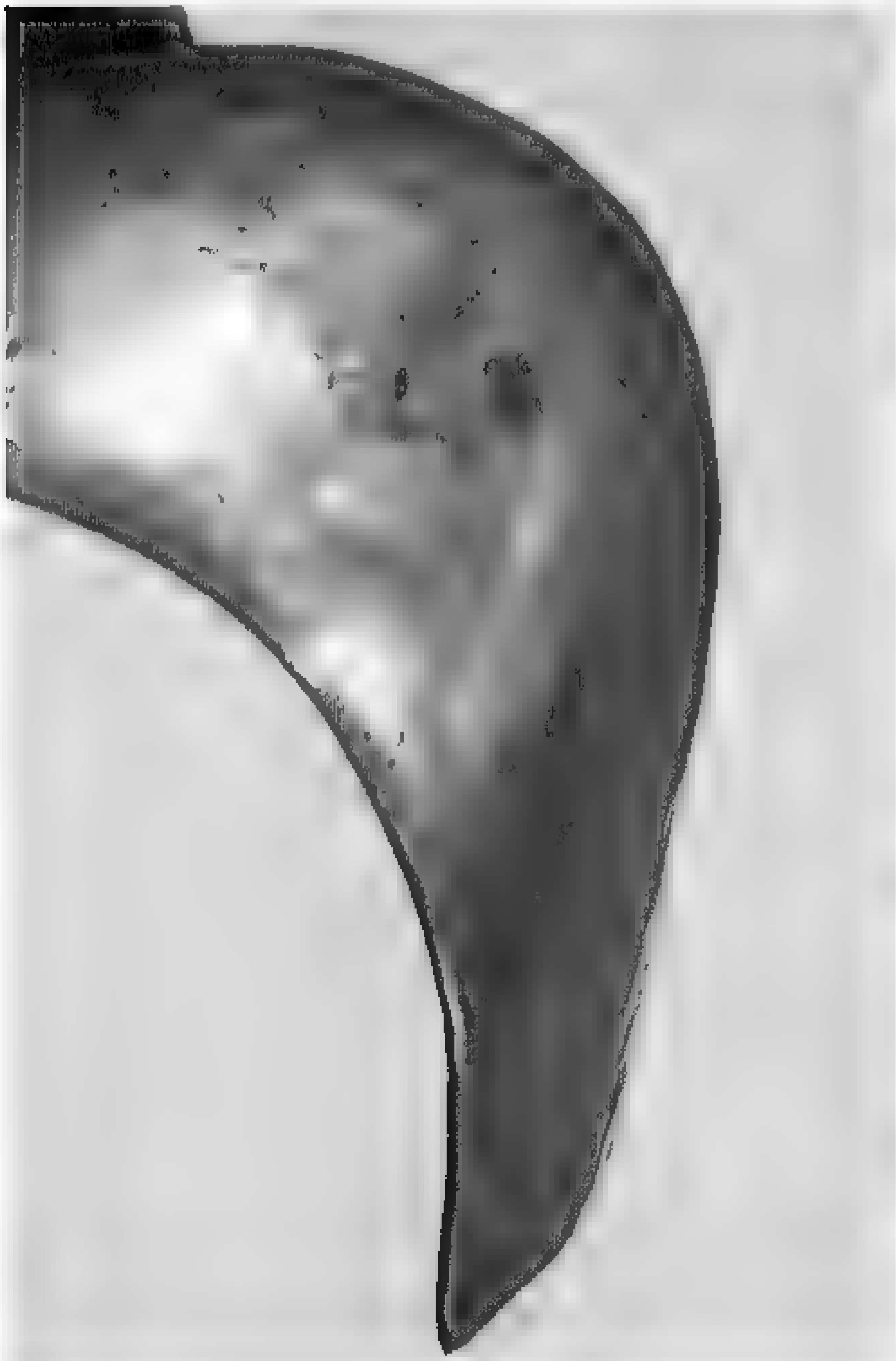


Figure 15.22. Results of deep doming a helmet (above) and a couter (left)

needs to be given to getting the resulting domed shape perfect, since it will be pushed out further at the next step.

Next the piece is pushed "free form" down into a deeper dish. It is not pressed completely into the dish (hence "free form"), so the armourer must use his eye to determine when the right shape has been achieved. This can be done in an old oxygen cylinder (fig. 15.20), deep wooden dish, sandbag, or even just a ring of metal. The steel dish yields the best result; the stump or sandbags work well, but they do take more time.

When doming into the deep dish, work carefully from the outside inward, guarding against creasing. Creases are formed when too much force is applied to the piece and the metal buckles as a result. Some light creasing can be expected even in good work, but any crease must be removed immediately or the piece could be put at risk.

When dishing with a steel hammer as on the couter examples below, be very conscious of working from the edge and pushing the metal inward as if it were a viscous liquid. If you fail to do this, the piece can be thinned excessively and even pierced completely (fig. 15.23). Note that very deep shapes such as couters and articulated poleyns are risky to form via doming because they are easy to thin in the process.

In Figure 15.21, a couter is domed into a deep dish. Notice that the areas at the edge have been domed first, leaving the metal in the center. In this case special care has been taken to push the metal from the edges down into the dish, hopefully counteracting some of the thinning that always accompanies doming operations.

Unless fortune has it that the dish is precisely the depth needed for the final piece, the piece will have a lumpy appearance as in Figure 15.22. This is removed by returning the piece to the shallow dish for bouging (as in the

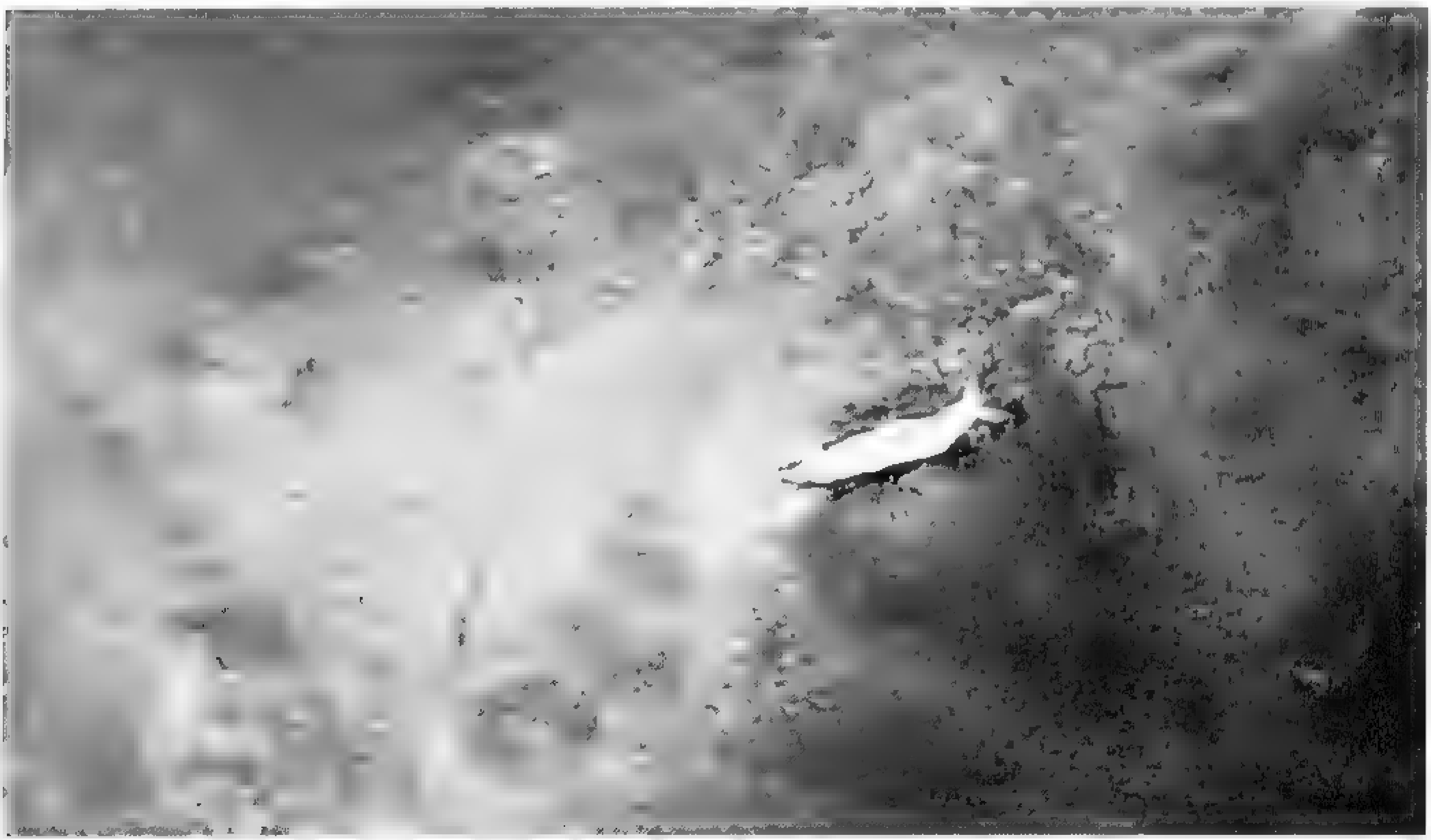


Figure 15.23. This poleyn was thinned to the point where it tore while being worked into a steel dish with a steel doming hammer. Shapes like this are generally better raised than domed, although intermediate armourers often neatly sidestep the raising by creating the piece in two parts with a central weld. This reduces the depth of the required doming and speeds production considerably, though it is not a medieval solution.

case of a helmet) or continuing to form from the outside with raising or bouging techniques.

Doming Tips

When working over a steel dish, be prepared for a rather shocking vibration that can sting the off-hand. This will disappear when the piece is held at the proper angle relative to the dish itself. Wear heavy gloves to help counter the effect. Use a very heavy rawhide hammer and don't be afraid to really whack the piece—heavy steel is resistant to deformation and must be coerced with heavy doming techniques. (With raising it's more of a coaxing/persuading than forcing.) Wear ear protection when working with steel dishes. Keep the off-hand clear of the space between the work and the dish or severe pinching can result.

For small pieces that must be deeply domed, a lead block can be used as a temporary dish (fig. 15.24). I tend to use lead extensively in the formation of gauntlet parts since they are often deep and small. The necessary depression can be quickly formed by hammering directly into the lead or by hammering a form into it.

Flaring

Flaring can be thought of as advanced curling. Rather than forming a cylinder or cone, the resulting shape possesses a slight concave surface. This sophisticated shape is often difficult to obtain, since it is generally a compound shape working in two axes. Having a clear mental picture of the final result is crucial, as most flaring is technically difficult and mistakes are not as easily forgiven because the process tends to rapidly harden the piece. However, there is no substitute for flared work on the finer components of armour such as greaves, gauntlet cuffs, demi-greaves, helmet skirts, poleyns, couters, and even vambraces and cuisses. Flaring yields the graceful transitions that move one element to another, distinguishing a well-crafted piece of good lines from its clumsy cousin.

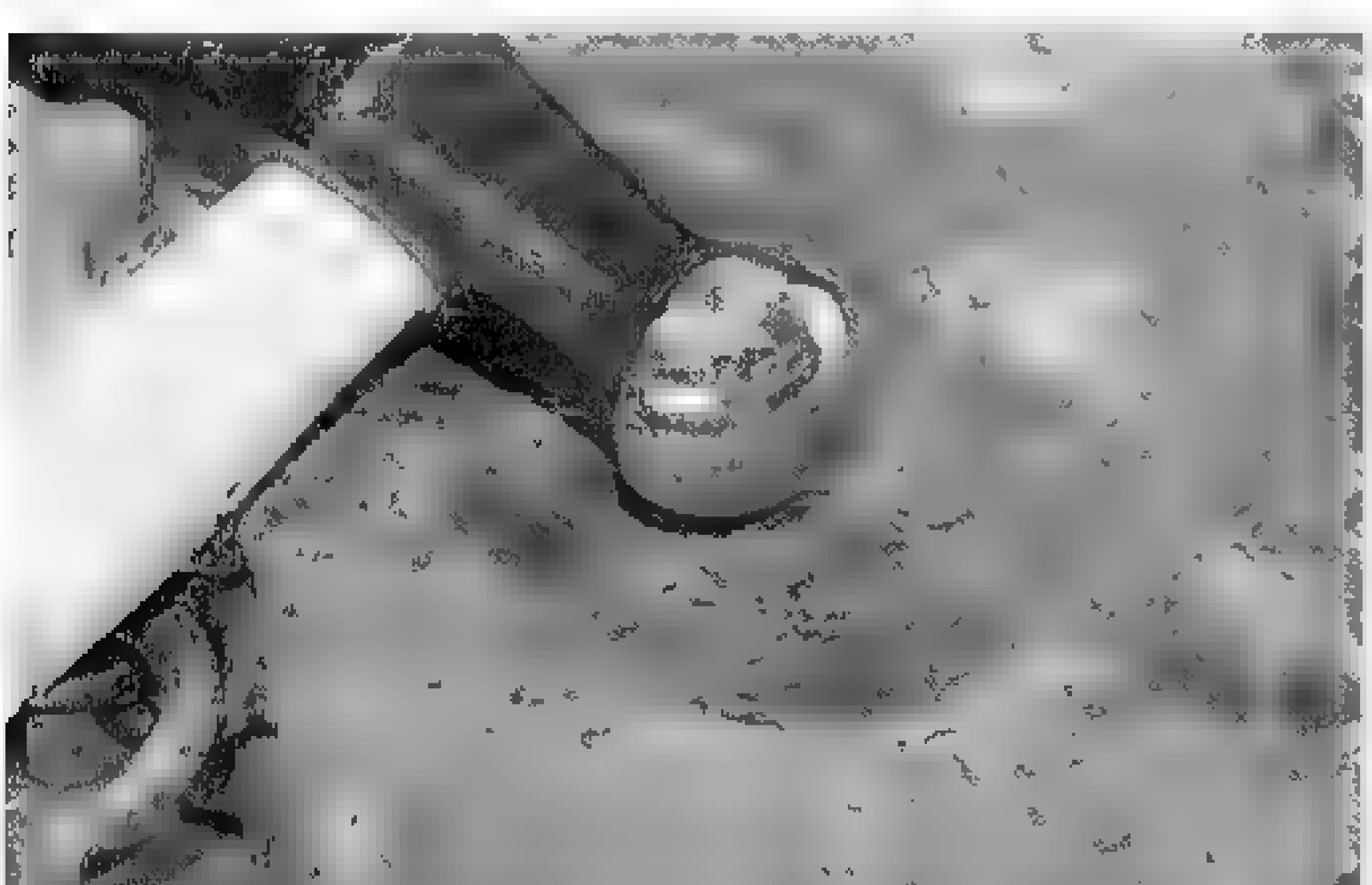
Internal Flaring/Stretching

The simplest form of flaring is done from the inside (fig. 15.25). Similar to dishing, it moves the metal by thinning it between the hammer and the stake. Working in evenly laid courses is crucial. The metal will harden quickly, so annealing or hot-working may be necessary for things like sallet visors, greaves, or the skirt on a barbute.

External Flaring/Compressing

The more advanced form of flaring requires the work to be done over the outside of the piece. Similar to raising, it moves the metal by thickening it as the piece is moved from a point suspended in the air to the stake (fig. 15.26). Though it is more difficult than internal flaring, it tends to yield far more even treatments and more subtle, pleasing shapes.

Using a domed raising hammer will prove effective, though for aggressive flares it may



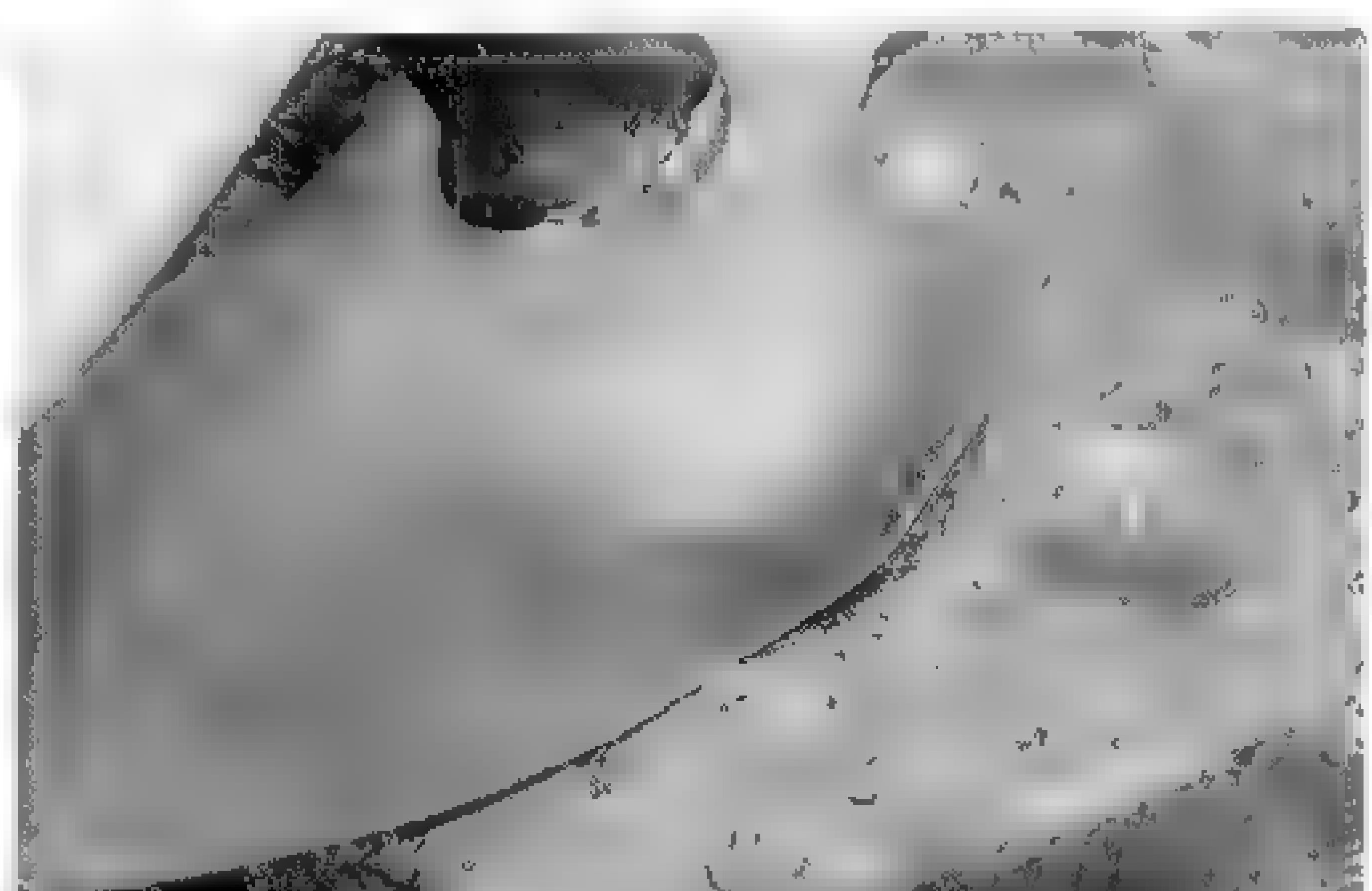


Figure 15.24 A doming setup in lead, useful when a small area must be deeply embossed

Figure 15.25. To flair the edges of a piece slightly, the metal can be stretched from the outside

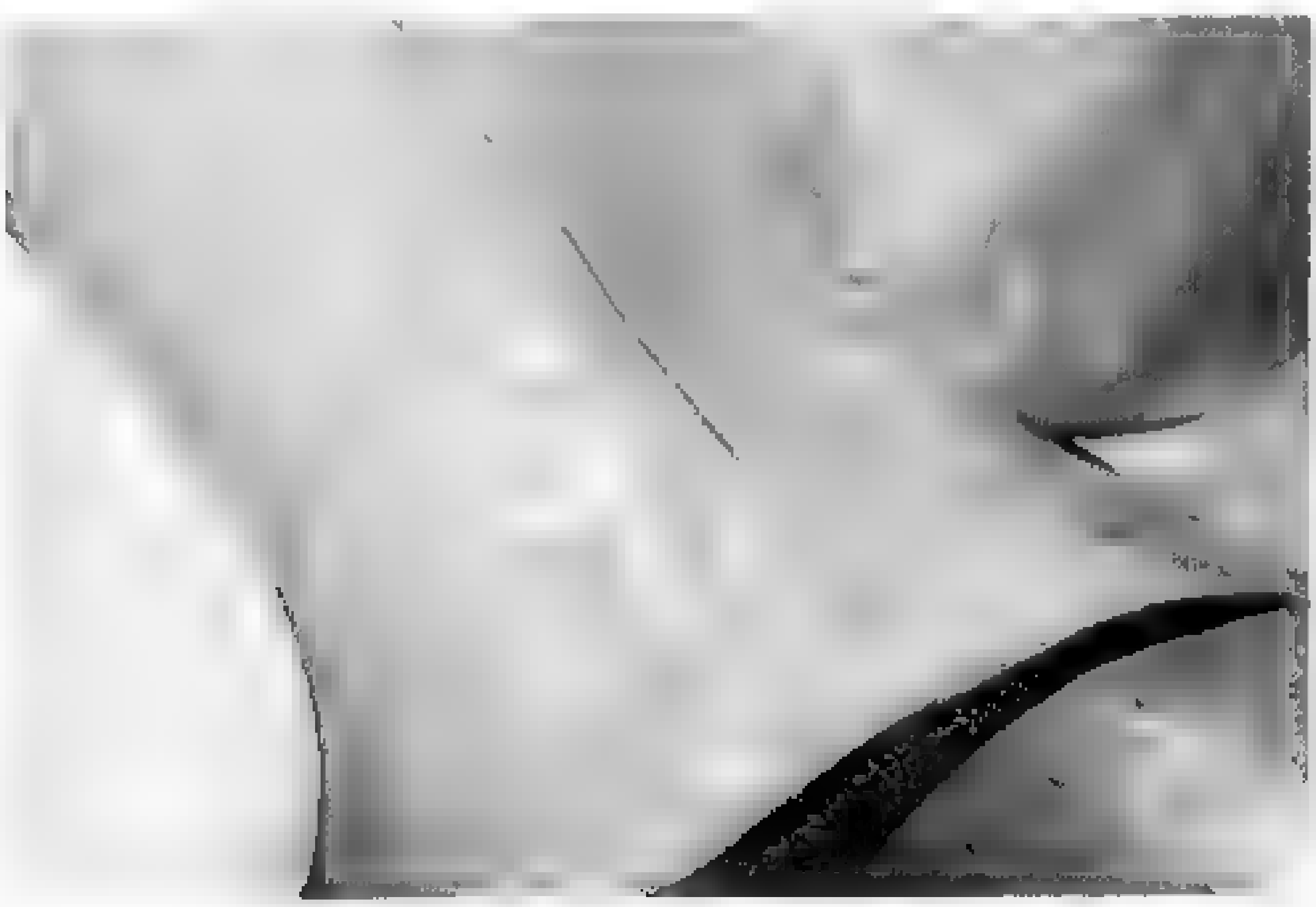


Figure 15.26 Flaring

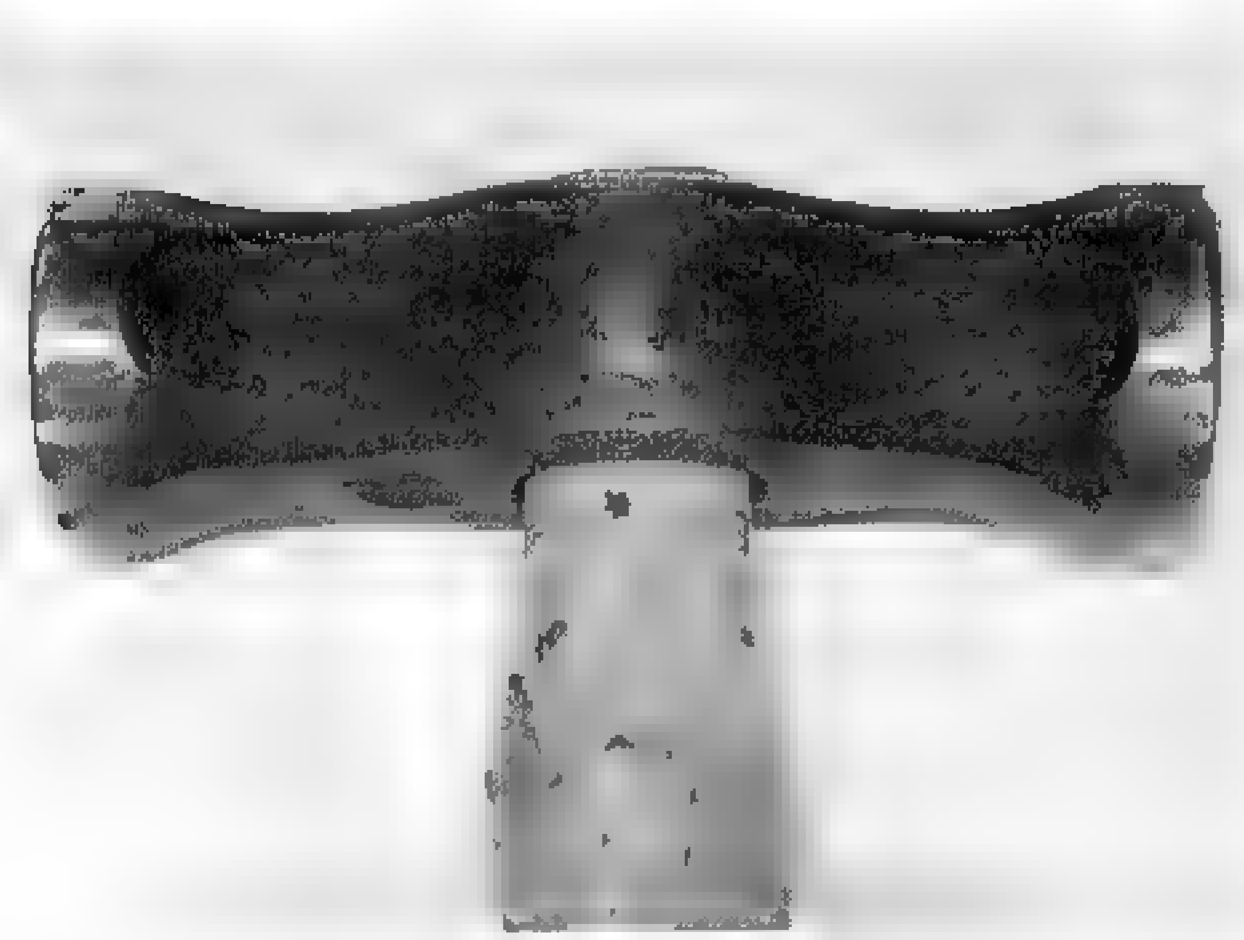


Figure 15.27. This hammer is exceptionally useful for bouging operations. The slightly domed face (shown left) works well when bouging from the inside into a dish or over an anvil face, while the flat face (shown right) is excellent for work from the outside over a rounded stake

well be necessary to use a narrower hammer face, which will score the metal more but move it about faster. Brace the work off of a T-stake and rest the edge on the stake. Strike perhaps 3/8 inch above where the piece contacts the stake, which will cause the metal to punch inward against the stake (fig. 15.26).

The piece must be consistently turned from side to side during the process; otherwise it will flatten quickly. The angle that the work is held at relative to the stake must also be even; otherwise it will twist and be too uneven to use.

Flaring is difficult, but it is important to master. Some have said that flaring is more difficult than raising, and this may well be true. Practice on samples to get the feel for the process before attempting to work on your first piece. Working in copper to learn the general angles and movements is a good idea too.

BOUGING AND PLANISHING

Once a piece has been roughly formed, whether by doming, raising, or flaring, it must be smoothed and finished. In silversmithing, two terms have evolved to describe these operations: bouging and planishing.

Bouging

Bouging involves removing the largest high and low spots in a roughly formed piece. The largest of these can sometimes be addressed in a dish with a rawhide hammer. However if a piece requires a great deal of bouging, then the rough-forming phases were not completed and the project will suffer. Bouging should be a quick-fix pass designed to repair gross errors.

Most bouging is accomplished from the outside of the piece using a large, smooth-faced, highly polished hammer. I find that the heaviest hammer available serves this function best; I prefer one with a slight dome on one side and a flat face on the other. Bouging can also be done from the inside using a slightly rounded-faced hammer (fig. 15.27). Generally a heavier hammer is better than a lighter one.

In generally going over a piece during bouging, the armourer will want to remove high and low spots while also correcting any

twisting or deformation that has occurred during the rough forming steps.

Raising a Low Spot

Probably the most common thing that an armourer will need to do during bouging is to raise a spot that is too low. This can be done in two ways: from the outside or from the inside. To raise it from the inside, simply place the domed plate into a dish, sandbag, or stump (fig. 15.28). Use a slightly domed hammer and hammer directly over the point that needs to be raised. This can also be done on a flat anvil face or over a railroad rail, although the armourer must hold the piece at the appropriate angle so that a flat spot is not created in the process.

Another technique that works well is to raise the offending area by placing the piece over a ball or other stake and hammering all around the low area with a flat-faced hammer (fig. 15.29). The stake acts as a lever and pushes metal up into the low spot, equalizing it nicely with the rest of the surface. I prefer this technique unless I happen to have a dish that has the exact dome required.

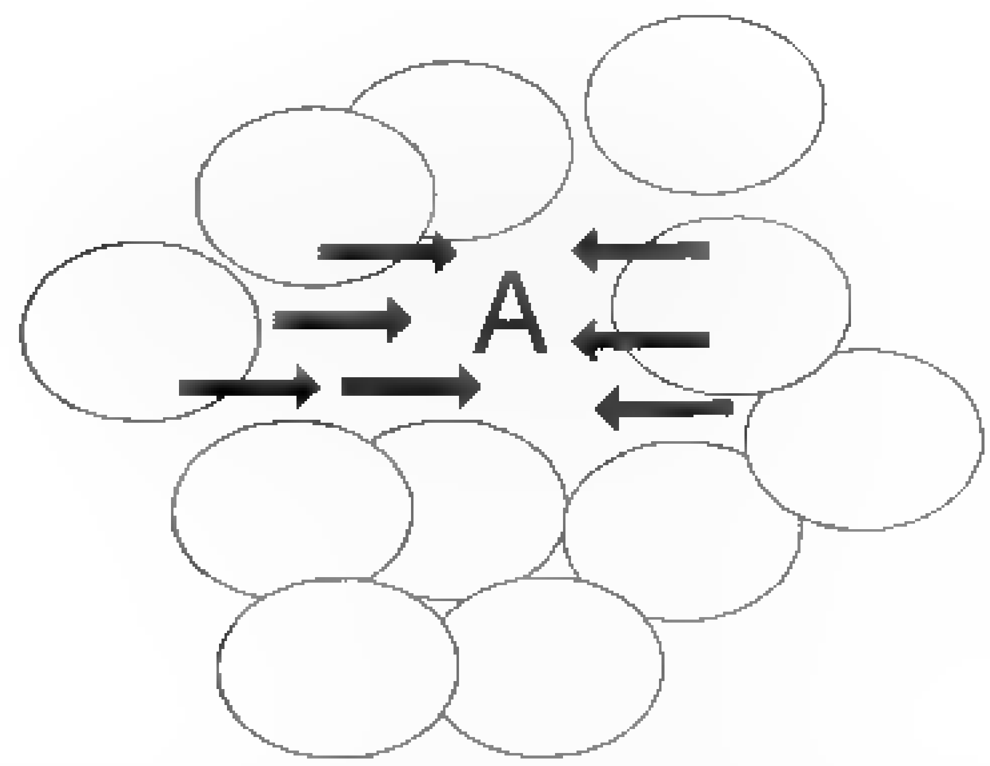


Figure 15.28. To remove a low spot from the inside use a slightly domed hammer face and strike the piece directly on the offending spot. In the illustration above, area A represents the low spot; hammer strokes should be placed at the arrow points, generally filling in the whole area.

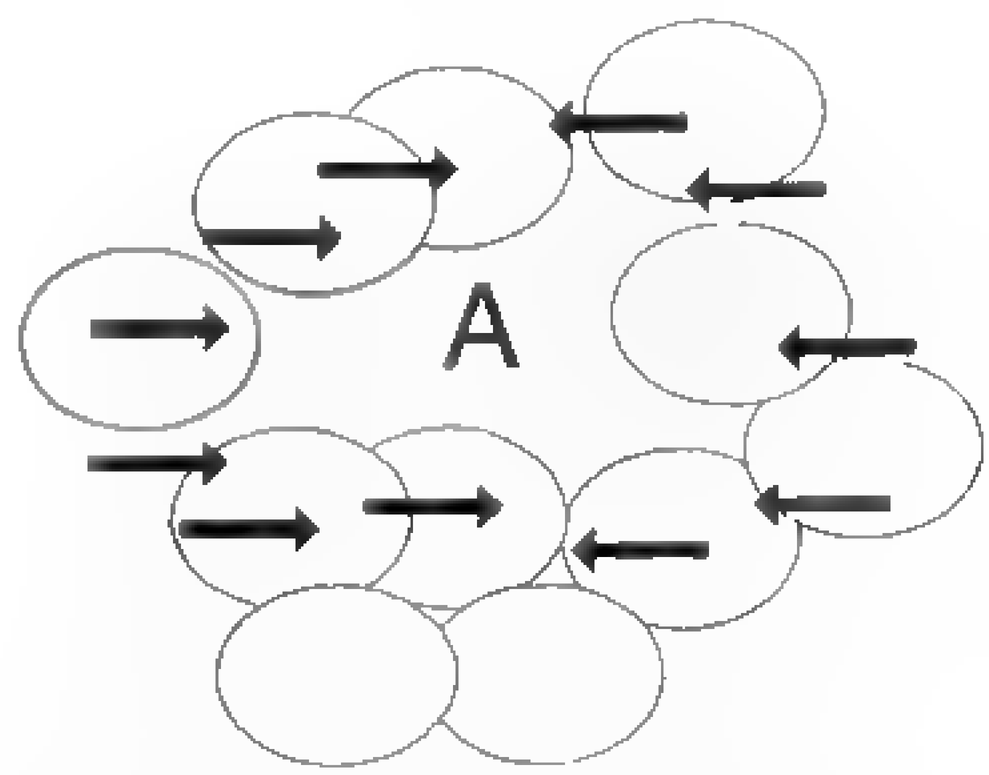


Figure 15.29. A low area can be best raised—albeit counterintuitively—by placing it over a domed stake and striking all around it with a flat-faced planishing hammer. The result is even and easy to control, if a bit surprising. The stake acts as a counterforce that actually brings the metal up, while the hammer lowers the metal slightly around it. The equalized result is a very even, smooth arc

Lowering a High Spot

High spots are almost always removed from the outside with a flat-faced planishing or bouging hammer. The piece is braced on a rounded stake that contacts the area immediately next to the high spot and the spot is hammered directly, forcing it down to contact the stake (fig. 15.30). The border area between the repair and the existing dome is then finished by planishing directly on the ball or mushroom. As with any bouging operation, keen use of light reflected from the surface can tell the armourer when the job is complete.

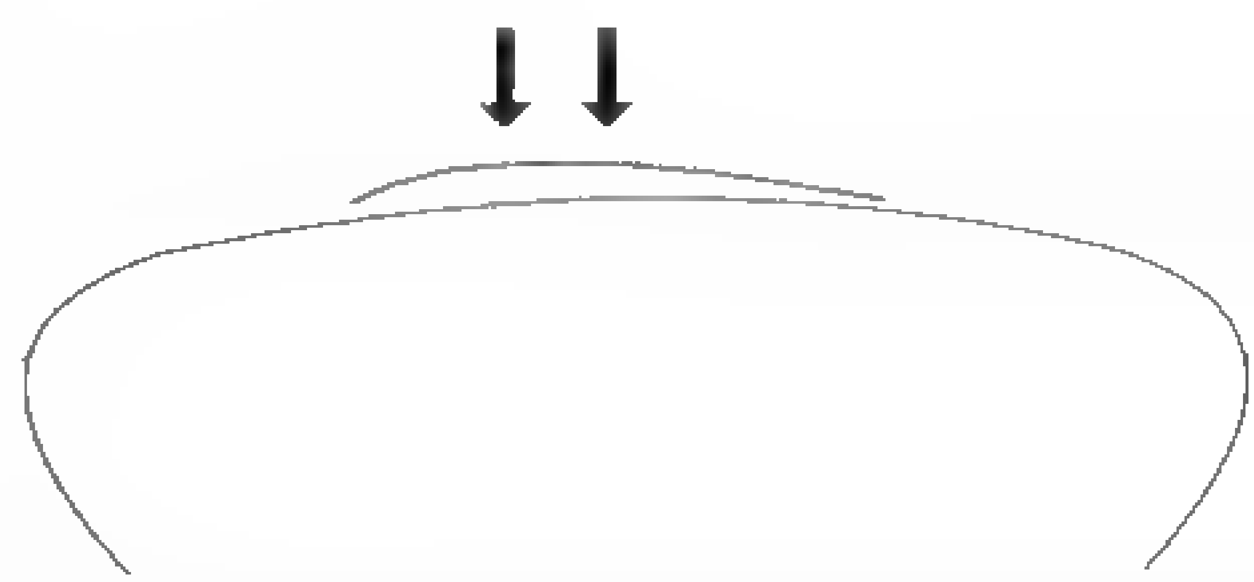


Figure 15.30. Although greatly simplified the illustration above shows how high spots are removed using a planishing or raising hammer and a stake. Strike downward directly over the high spot to remove it; it will conform to the shape of the stake

Planishing

Once bouging has been completed and all the gross twists and high and low spots removed, the better pieces are then planished, or smoothed, with the hammer. Planishing is generally done from the outside, using a very highly polished, wide-faced hammer (heavier is generally better), using overlapping blows to create a pleasant faceted effect.

To planish a piece, it is placed face-up over a stake. Working evenly from either the edge or center, overlapping hammer strokes are delivered (fig. 15.31). The resulting piece bears a faceted appearance that can be easily finished. Medieval munitions equipment was often sold at this stage of completion, though only a few 16th and 17th century examples in this form have survived to the present day.

Domed surfaces are generally planished over ball or mushroom stakes, while flares are usually planished over a T-stake using a slightly domed-faced hammer (fig. 15.32). As with forming, work in careful passes overlapping each hammer blow slightly over the last to create a faceted pattern very similar to that pictured in Figure 15.1. A larger hammer face and wider ball will yield larger hammer marks, which will make the work go faster. A flared surface is planished with the same technique, except that instead of a flat-faced hammer, a *very* slightly domed hammer face should be used

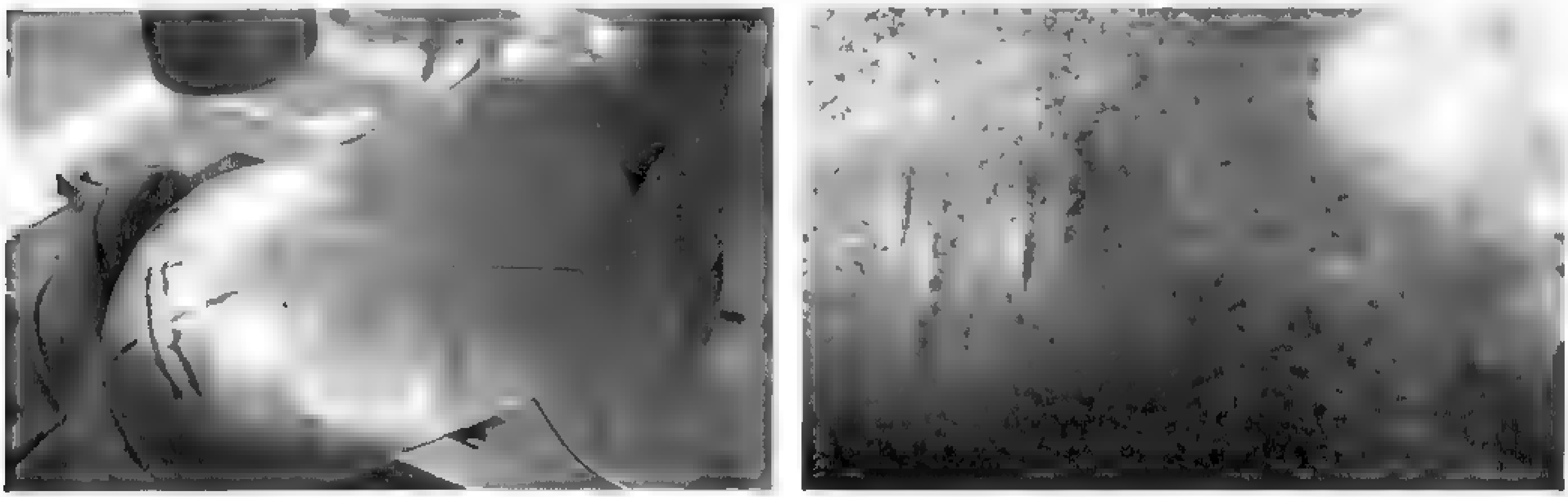


Figure 15.31 When planishing a domed or raised surface, there may be a tendency for half-moon-shaped dings to show up in the metal's surface. This is the result of tilting the hammer to one side or the other. Each of these crescents will take two or three well-placed hammer strokes to remove, so it can quickly get out of control if the armourer is tired

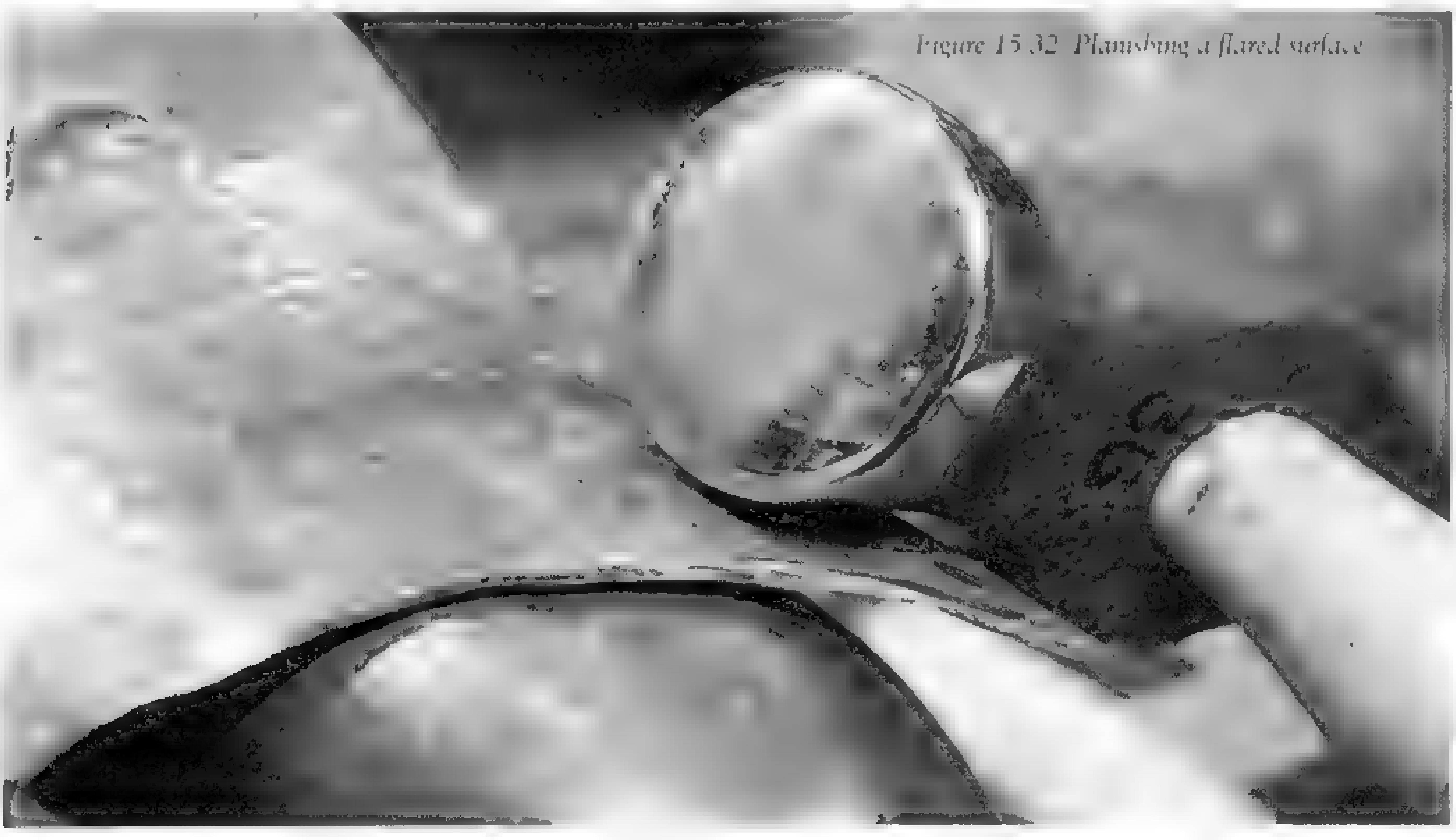


Figure 15.32 Planishing a flared surface

Chapter 16

Enhancing Techniques

Very few examples of medieval plate armour remain that do not have some enhancement done via hammerwork. Nearly all are strengthened and gain a crisper appearance through the addition of creases and rolled edges, while others are even more elaborately strengthened through fluting, large rolls, and embossed borders.

The quest for increased plate strength drove the development of enhancing hammerwork, but the techniques used and their method of employment conformed to artistic traditions of the age.

During the 14th century, pieces were often strengthened through the addition of creases (also called central or median ridges), embossing, and rolled edges. The crease adds rigidity while providing definition and conformity with the favored arch shape of the time. Rolls both strengthened edges and helped to prevent the intrusion of a sword or lance point into the gaps between the armour, as at the neck and arm holes of a cuirass or at the top of a cuisse.

These enhancements represent the extent of what was done through hammerwork during the transitional period. Much more enhancement was obtained sense through the use of color and multiple materials such as leathers, paint, and contrasting metals such as latten or gold wash.

Opposite page: Figure 16.1. Embossing, creasing, and fluting were all used on this beautiful Gothic gauntlet by James Gillaspie. Although armour from the transitional period did not make use of the attractive fluting or piercework common to Gothic pieces of the 15th century, the techniques of embossing, creasing, and edge-rolling were employed throughout the 14th century.

Most of the enhancement on harnesses of the 15th century, whether German or Italian, was accomplished not through the multimaterial colorfulness of the previous century but through skillfully hammered components. Their purpose was clearly functional, but they also enhanced and emphasized the cleanliness of line in the neoclassical artistic styles then in favor. Claude Blair has termed the 15th century the "Great Period," partly because the armourers' skill in hammersmithing achieved a rare balance between form and function, and partly because their work embodied a kind of elegant simplicity that is difficult to find before or after.

Fifteenth-century harness continued to rely on the strong median ridge as a defining design element, but it now was sometimes enhanced—especially in the German schools—by sprays of hammered flutes. These fans of flutes provided both the distinctive look to German harnesses and its substantial strength, enabling the armourer to use smaller, lighter plates.

Edges were often strongly rolled from 1420 onward. Large triangular or square rolls were used alongside the traditional smaller rolls of the transitional period. Rolls were generally though not universally made to the outside, and wires were sometimes incorporated into the roll to help preserve the shape

Throughout the century the armourer's craft became more specialized as larger enterprises were able to achieve economic benefits through division of labor. "Plattners"—those who formed pieces with the hammer—were both increasingly skilled in their niche and distinct from those who finished, polished, and strapped the final product.

This functional distinction gave rise to highly skilled hammersmiths such as the Negroli, Seusenhofer, and Peffenhauser families, who were able to craft the elaborate parade armour in the most baroque, intricate forms. At the other end of the spectrum, munitions armour was increasingly produced

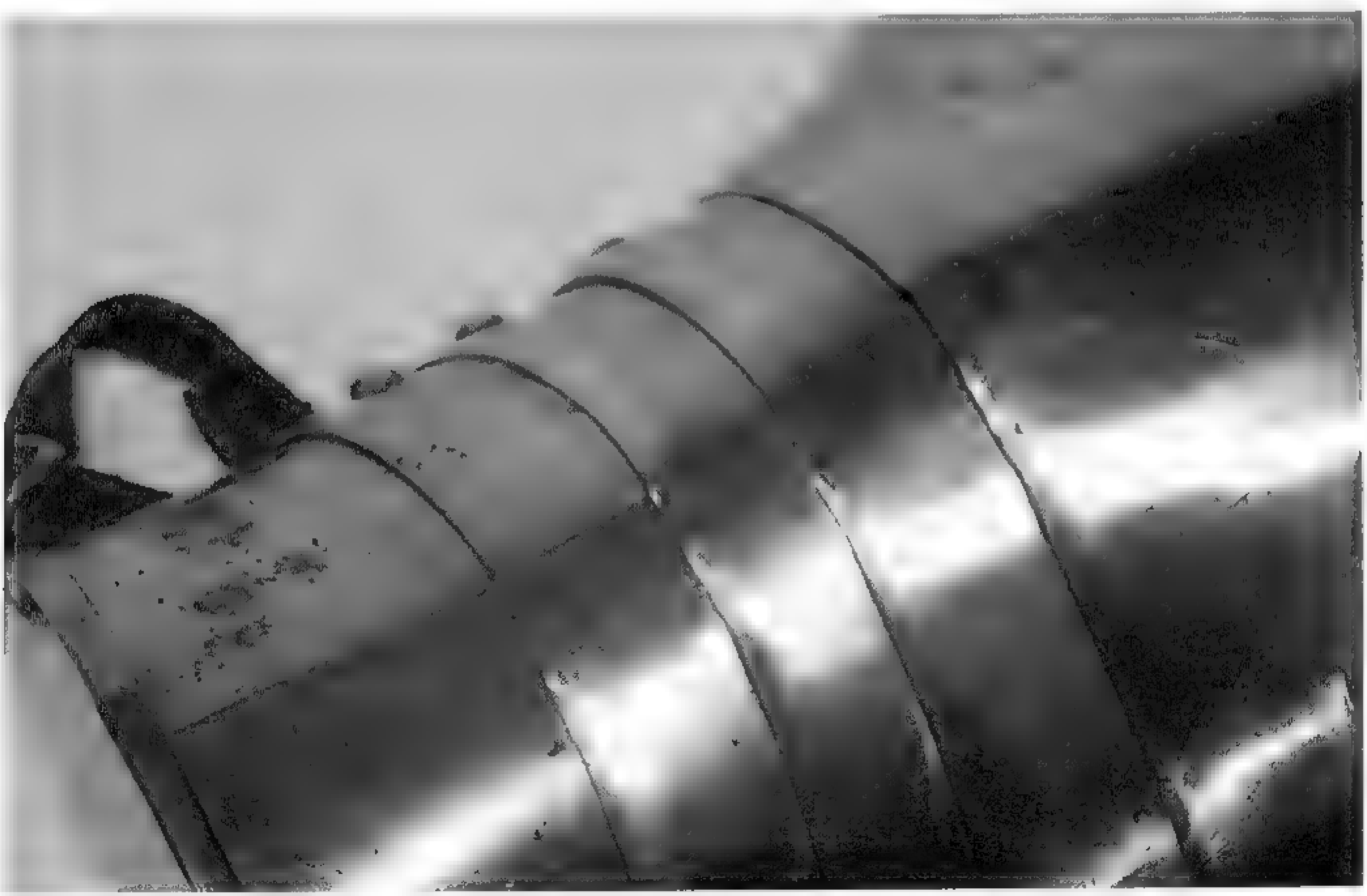


Figure 16 2 A crease helps to define simply curled pieces as well as lend them strength

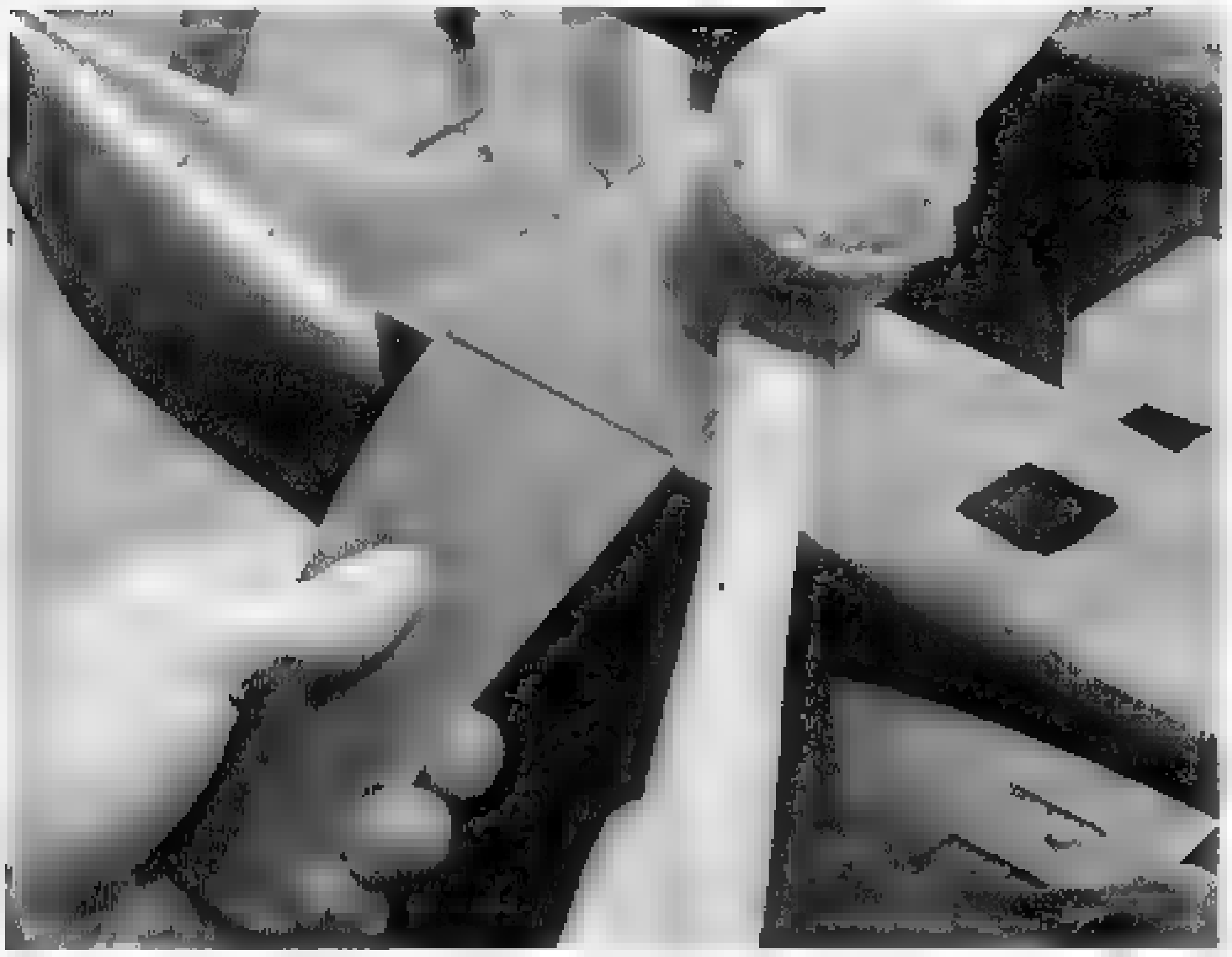


Figure 16 3. Creasing first step

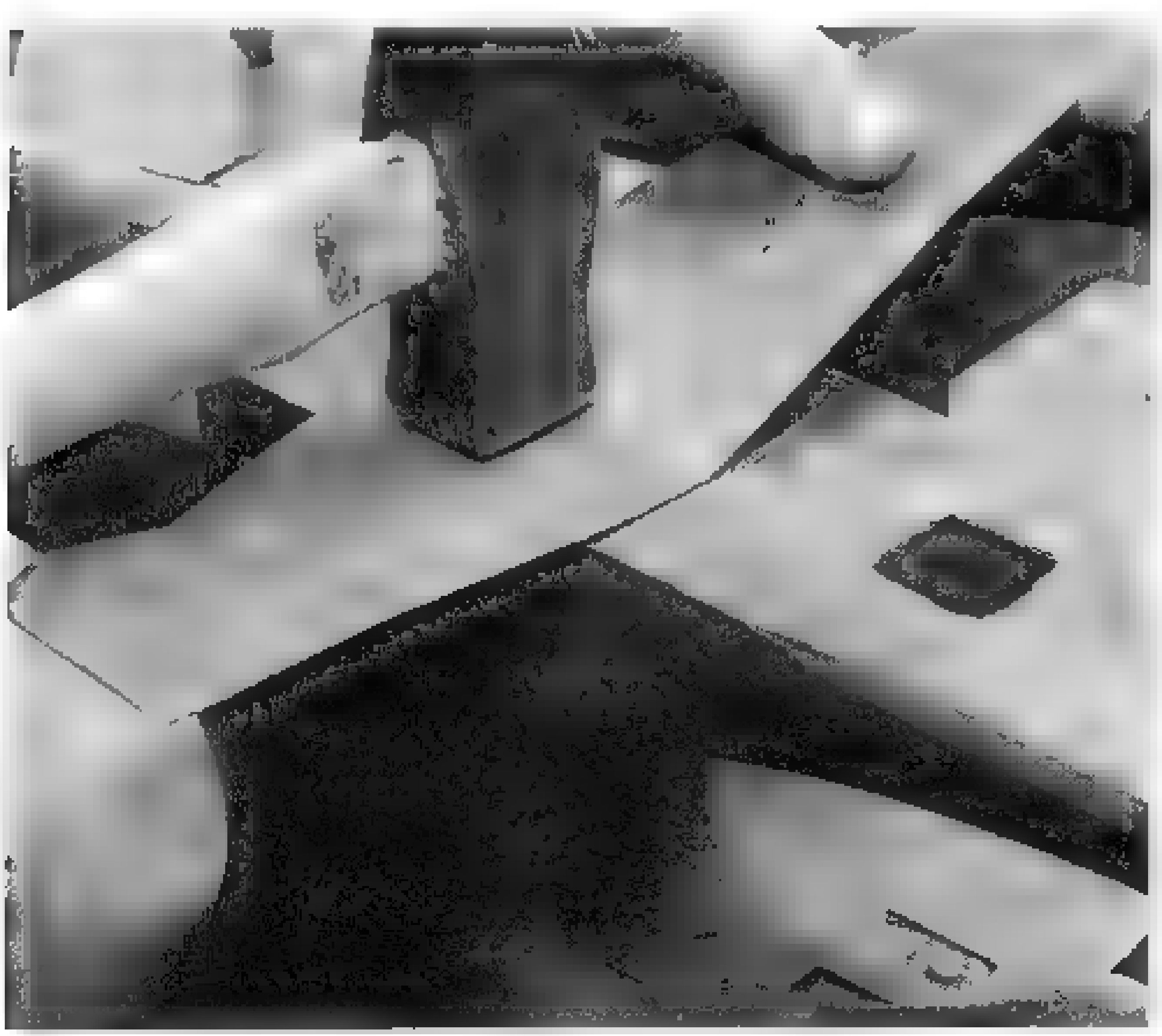


Figure 16 4 Filling in the recessed areas

via automated techniques such as rolling mills that reduced the artistic content while simultaneously reducing the time necessary to produce armour for the field. Sometimes these harnesses were even sent out unfinished, rough from the hammer

CREASING

For novice and intermediate armourers, working to create straight creases (and smooth rolled edges) will provide more than enough challenge. Creases in curled pieces or in domed plates should be even and straight for their entire length, a critically important element of achieving crispness in 14th century armour.

Theory of a Crease

A crease is essentially the point created by the juncture of two arcs. When viewed in three dimensions, this juncture becomes a straight line. Creases can easily be placed in plates that will be curled and, with a bit more care, can also be added to domed plates with great effect.

The crease is a defining element, providing a central anchor that contributes strongly to a piece's crispness by providing a line against which light can play to create the needed definition.

Creasing a Curled Plate

Plates that will be curled rather than domed or raised can be creased either before or after the curling process. For large pieces such as cuisses, the creasing can often be done in advance, the cuisse itself then curled and lined up with the already articulated joint for the knee. Lames should first be curled to conform closely to the elements with which they must interact, then roughly creased. After the final articulation of these pieces into the joint, the crease can be finished, insuring that it matches smoothly and in a straight line with the other lames, shells, and limb defenses.

The first step in creasing a flat or curled piece is to mark the centerline clearly. This can often be done simply by taking the pattern and folding it in half. If you use file folders as stock, then most of your patterns will already have a

convenient centerline upon which the crease can be based.

For simply curled plates, the crease can be added either before it is curled or after. If adding a crease to a legharness or other articulated defense, be careful to first get the articulation points set—if you do not, the crease will likely be crooked because the plates will move slightly. Therefore for most leg and arm harnesses the creasing should be done after the articulation has been completed.

There are many occasions, however, where a crease can be laid in advance, and this is what will be illustrated first. Lay the piece on a sharp-edged surface on a good anvil or bichorn. Use a light rawhide mallet (sometimes you can do this with just your hands) and "brake" the metal to an angle of approximately 120 degrees (fig. 16.3).

The next step is to flatten the areas on either side of the crease using a flat-faced planishing hammer (fig. 16.4). A square-faced hammer will yield the best results, since the metal must be pressed right up to the crease. Looking at the piece from the end should confirm a nice 120 degree angle with no divots on either side of the crease. Hold the piece up and use light to examine it to insure that this is true.

Once the piece is flat and true, all that remains is to sharpen the crease using a flat-faced hammer over a very sharp edge or horn (fig. 16.5). Work carefully, moving from side to side and trying to get the crease dead straight (fig. 16.6). Use caution, however, not to work the piece too much or you can weaken it along the crease. As one of my apprentices once found to his dismay, you can cut a piece in half if you work it too much.

When the planishing has left a smooth, straight line, the piece can be curled as usual and then sanded to yield a perfectly straight crease. The trick then is to articulate the piece such that the crease lines up perfectly with the elements on either side of it so that the straight line does not break.

Creasing a Domed Plate

The creasing of a domed plate is a bit more

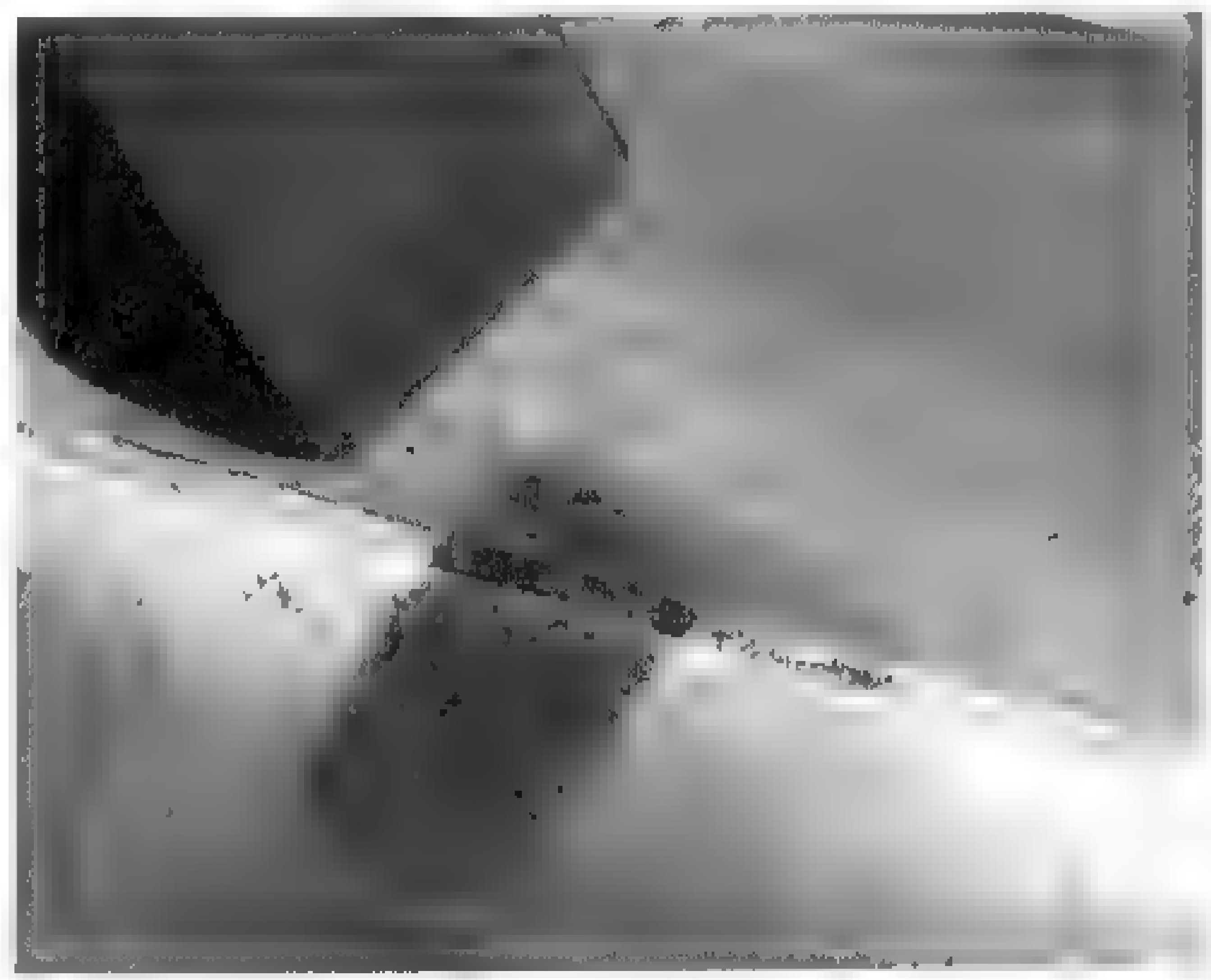


Figure 16.5. Planishing the crease.

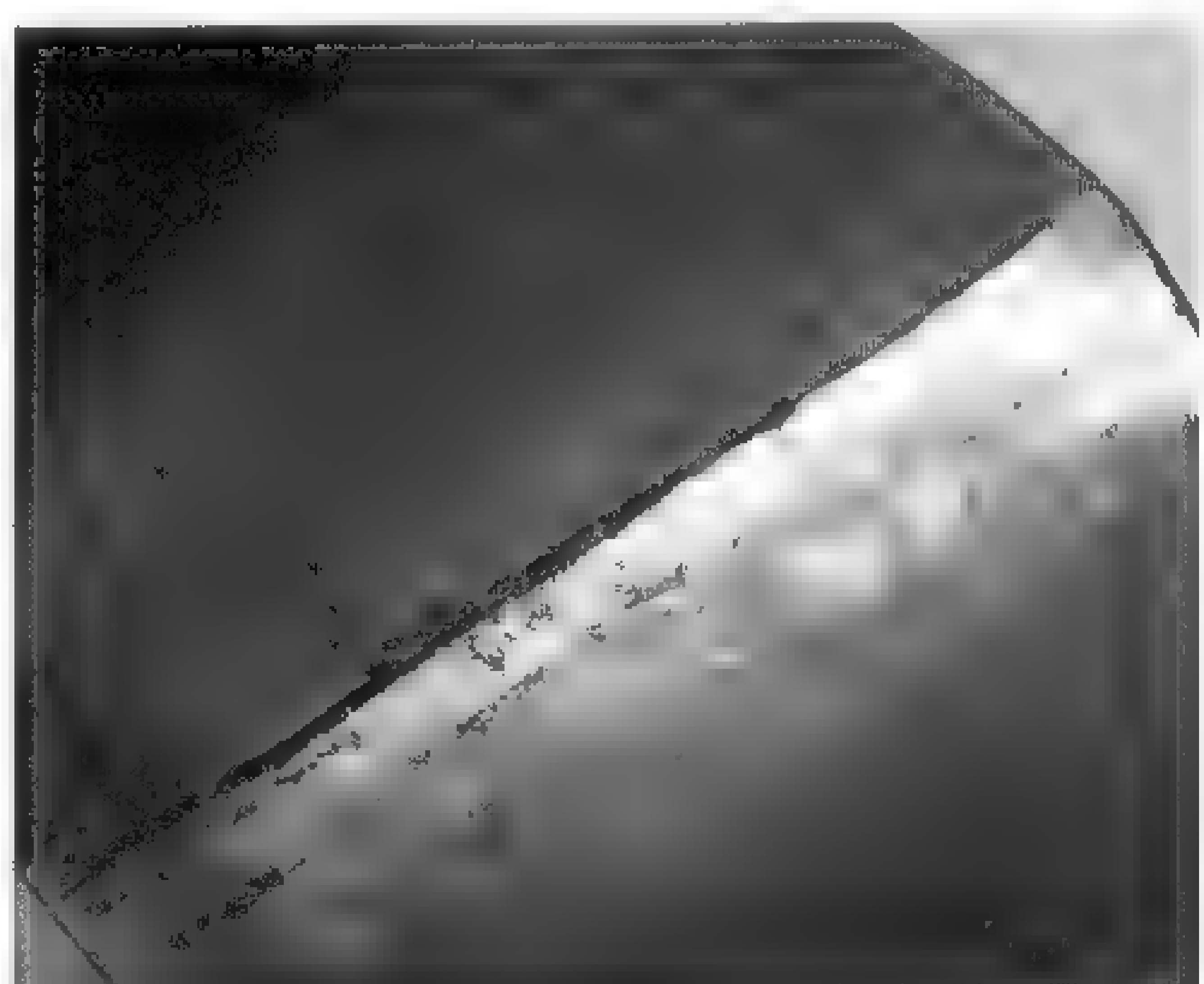


Figure 16.6. The finished crease

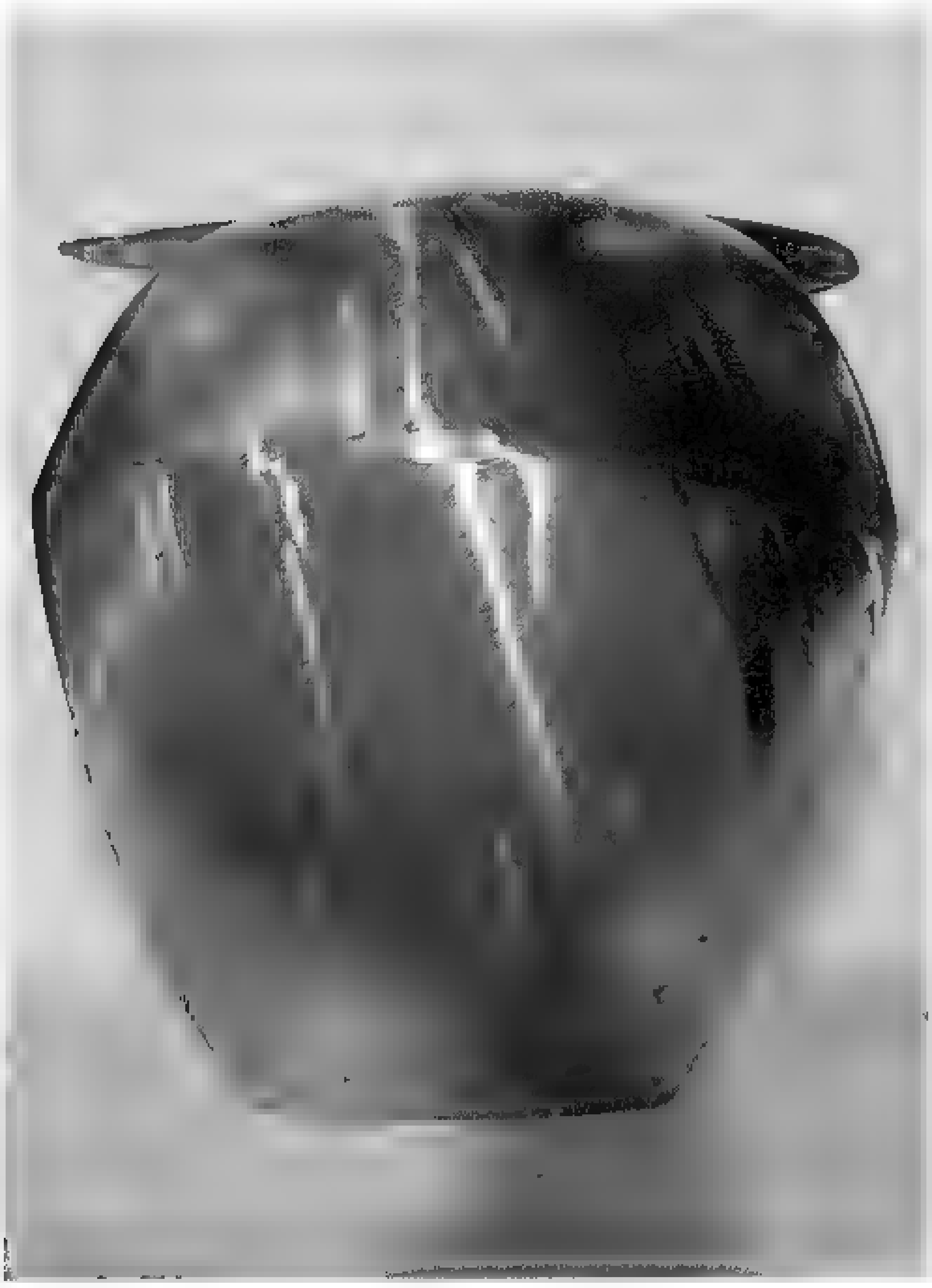


Figure 16.7. A finished, creased poleyn

Figure 16.8. Setting the crease in a domed plate over the creasing stake (fig. 6.45)

complex than it is for curled ones. There are several methods for achieving this effect, but this is the one I have found most effective.

First, the crease is marked on the front and back of the piece before any forming is done. This centerline will offer a guide in the raising or doming process, though it must sometimes be renewed as forming progresses or it can be lost.

The piece is then domed or raised as required, then set against a creasing stake (see fig. 6.45) and the area directly on either side of the crease "backraised" into shape (fig. 16.8).

This backraising has the effect of making a rough flute (fig. 16.9). The armourer can become skillful enough to where little work is required past this point. Most, however, must then work this backraised area into alignment with the crease and the arc on the far side so that the metal flows smoothly, transitioning from a broad arc that ends in a crease.

Once the backraised section is set, the depressed areas of the flute can be reset to the proper level by working the lowered area either in a large, shallow dish or on an anvil face. It can also be completely worked from the outside over a ball stake. While this technique requires more practice, it is superior because it gives the armourer better control over the final shape.

Once the backraised areas have been filled in, the piece can once again be worked gently over the creasing with a (preferably square) planishing hammer. This should yield a crease that is both straight and sharp (fig. 16.10).

Do not oversand a crease; the metal is by definition already thinner directly over the crease and can easily be thinned excessively during the finishing process. If the metal discolors during sanding, there may be a thickness problem.

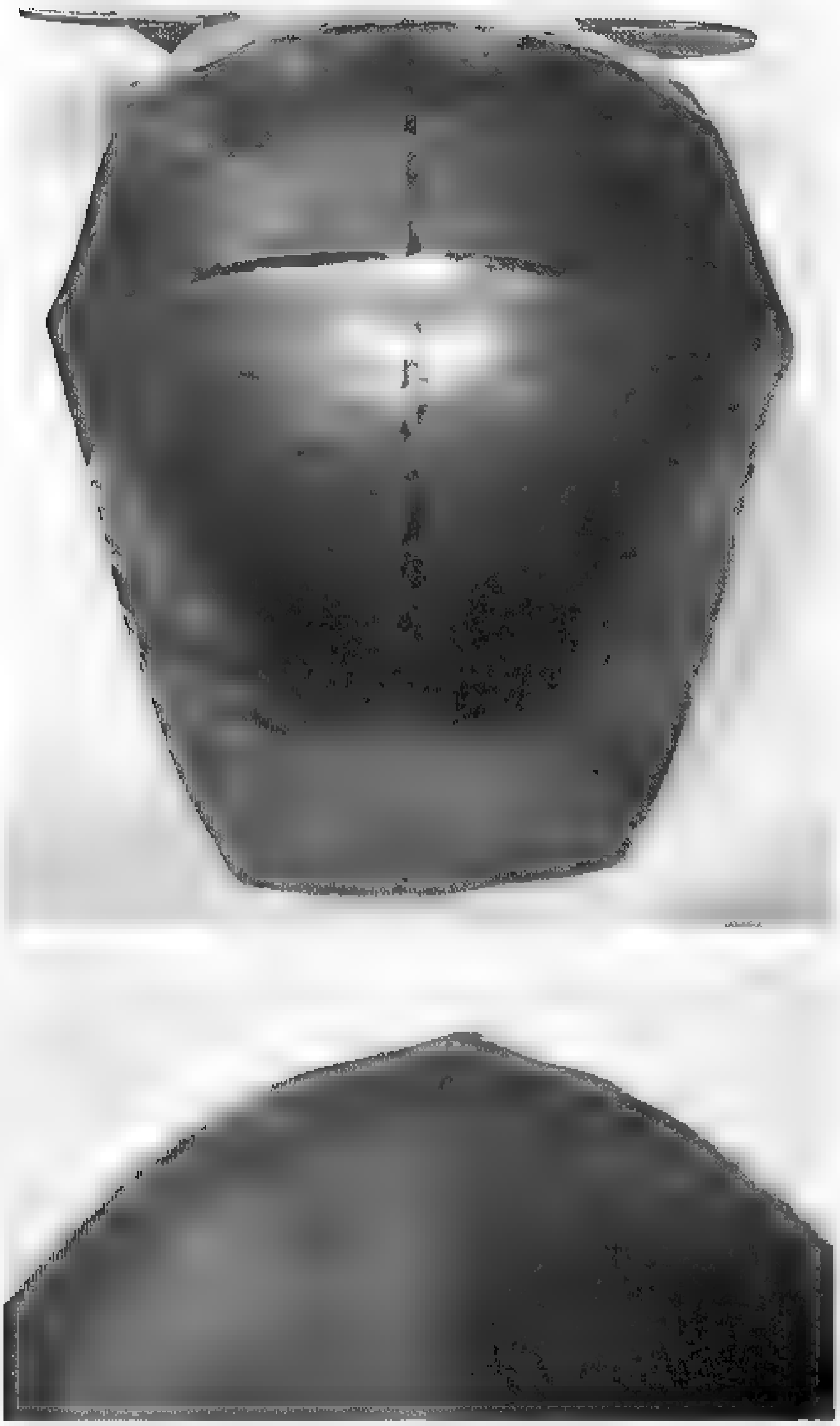


Figure 16.9. Creasing pass before bouging

EMBOSSING

After creasing, embossing is just a few steps up the ladder of technique. Embossing is decorative modeling done over a creasing stake. Small stakes are generally more useful for intricate work, while large ones are well-employed where long, straight, embossed sections are desired.

During the 14th century, embossing was used extensively in the reinforcement of gauntlet metacarpals and on the wings of both poleyns and couters. Besagews were often embossed as well, and embossed edges were sometimes (though rarely) employed as an alternative to fully rolling the edge, as is done on the chapel-de-fer in Figure 16.12.

I have found that the best hammer for embossing is the medium-light weight hammer with a highly polished square face. Some armourers have made use of tooling that fits into a swedge (a manual or mechanical die holder) to do their embossing or fluting, but I have not yet seen examples of such mechanization prior to the 16th century. Embossing tools such as a swedge would have left telltale tooling marks on the unfinished back of the piece.

Most embossing is done along a piece's edge to strengthen it. Likewise, on the tops of barrel helmets and the heaulm created in Chapter 30, it is used to turn the edges to meet other surfaces.

When I emboss an edge, I first "freeze" the metal from moving by working it over a sharp edge to make a crease. I do not try to rough the shape and then planish it, as is done with a crease, but rather have found better success hammering in one or two passes straight through, working very slowly and systematically from one side to the other.

Figure 16.10 The finished crease in a domed surface

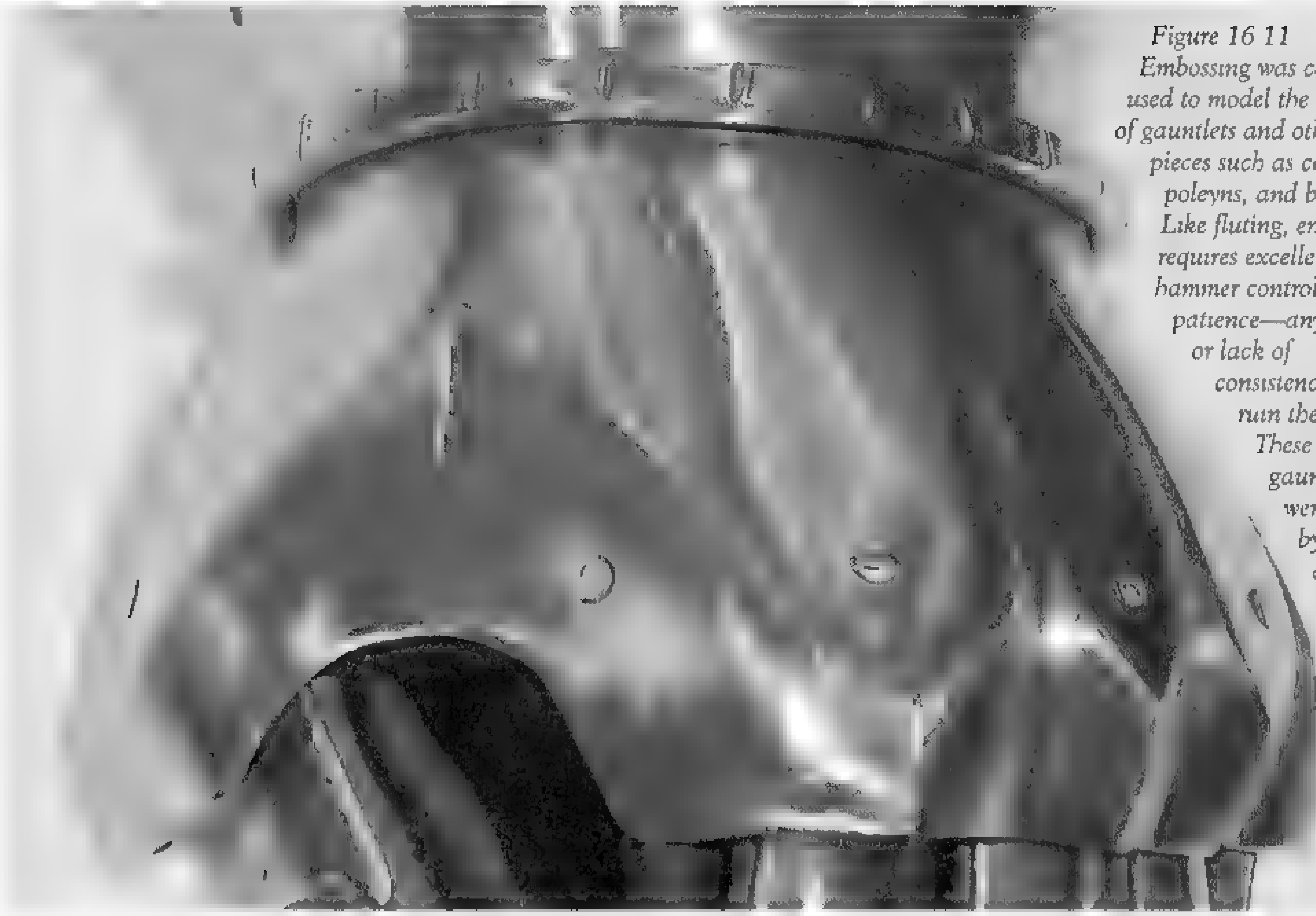


Figure 16 11 Embossing was commonly used to model the surface of gauntlets and other small pieces such as couters, poleyns, and besagews. Like fluting, embossing requires excellent hammer control and patience—any rushing or lack of consistency will ruin the piece. These gauntlets were made by the author in 1990.

Figure 16 12 A finished chapel edge and the appropriate technique

Do not jump around or your work will be extremely uneven. Ideally, a single pass should move you from one side of the embossing to the other without the need for "repair" hammerwork. Practice on some pieces to get this technique down; it takes some time but is well worth the investment.

For more complex pieces such as gauntlets, the embossing must be done even more carefully, and the armourer must not give in to the temptation to move too quickly from side to side. A single careful pass is generally all that is required—multiple passes will likely result in a total mess.

For the gauntlets pictured here, I worked over a short, sharp creasing stake (fig. 16.13). Your metal should already be planished enough that it could be sanded, since there will be no other opportunity to complete the planishing after the embossing is done.

The creases begin from one edge and move along the whole gauntlet from side to side over the course of perhaps 45 minutes of intensely focused work (per metacarpal). Little

hammerwork, if any, is needed after this is done. The metacarpals are sanded immediately and can then be polished.

FLUTING

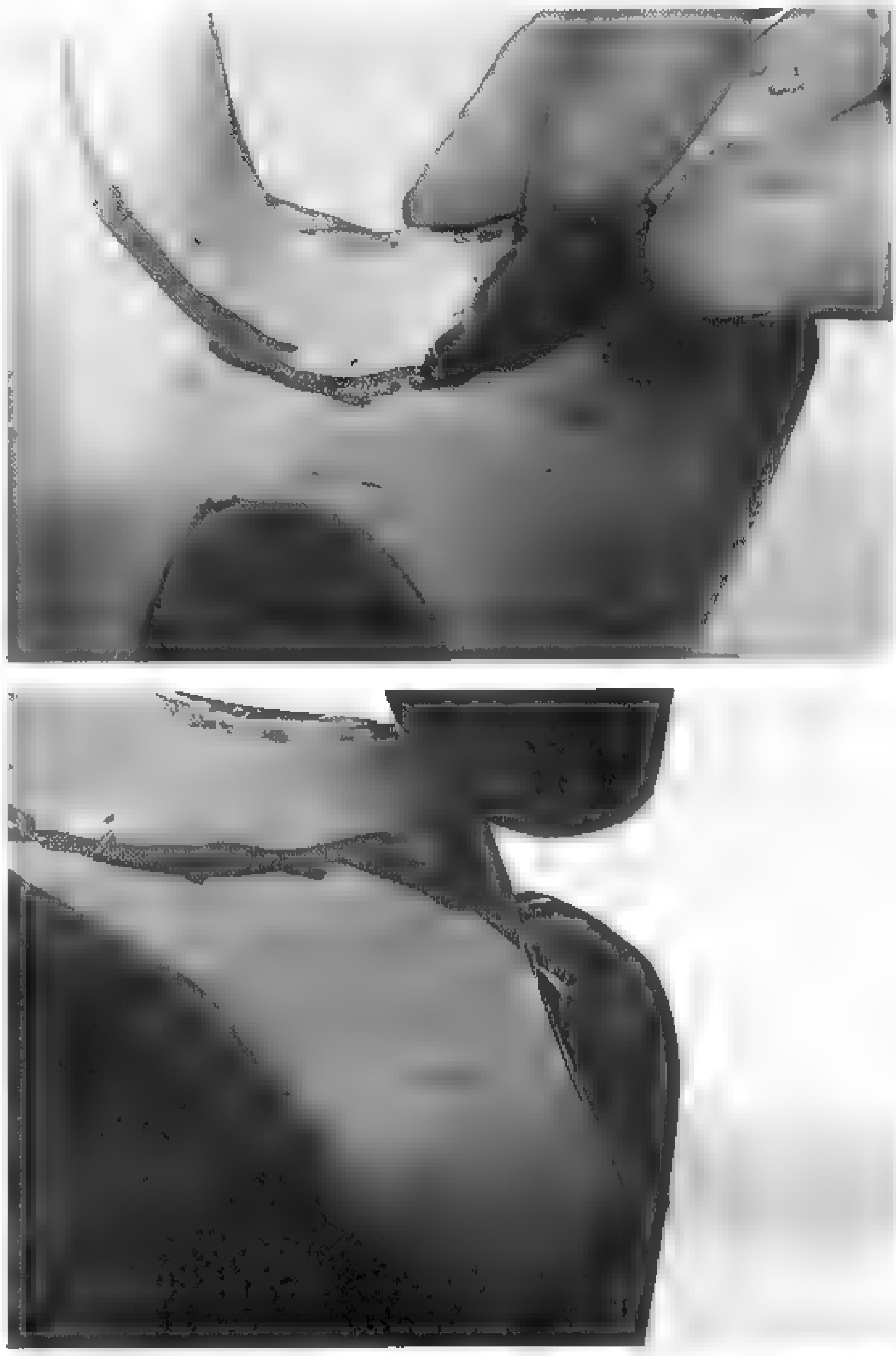
While fluting was not used extensively during the 14th century, German armourers in particular favored it during the latter part of the 15th century.

Contrary to common belief, fluting seems to have been done from the outside, not from the back of a piece with a chisel. If done well, using an ordinary creasing stake and polished square-faced hammer the flutes can be done in two passes, one down each side of the flute.

Early flutes have a characteristic concave shape to them, unlike the convex rounded flutes of the early 16th century Maximilian armour. The latter were very possibly laid into the metal using the aforementioned swedges, but the examples of Gothic armour I have been able to examine have hinted that the work was done with a simple hammer and creasing stake, as will be done on the chapel-de-fer example that follows.

Once the location of the flute has been marked, the armourer clamps a creasing stake firmly into a vice or stake plate. Adequate light and a firm set of the stake are crucial to success. The hammer face should be well-polished, since no additional planishing will be possible once the flutes have been laid.

Holding the hammer firmly, the armourer begins at the edge of the piece and works one side of the flute (fig. 16.15), being very sure to hold the piece at a consistent angle and striking consistently at the same point on the creasing stake with very



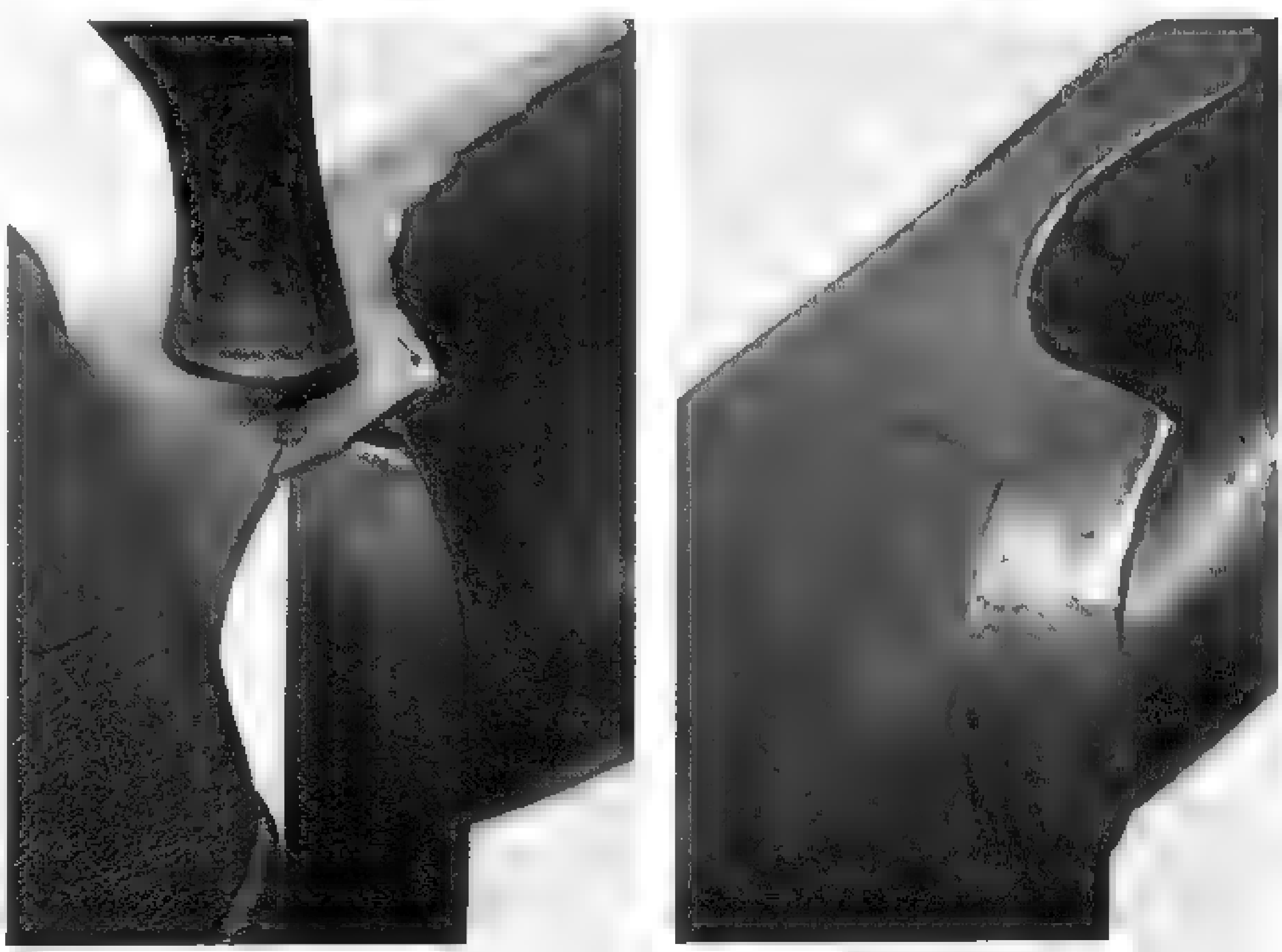


Figure 16.13. Embossing a gauntlet

even force. Variations in the angle, the point struck relative to the stake, or to the force applied to the hammer will all result in uneven fluting—something that cannot be easily removed. The hammer should make a solid "tinking" sound from its contact with the stake, and the flute should appear magically and somewhat mechanically as the armourer moves from side to side. Do not rush the process; patience and consistency are the qualities that lead to well-executed flutes.

If the flutes are viewed from the side, they should spray along with one even arc, not a series of rises and dips. If there are dips and rises, then one or more of the variables mentioned above was inconsistent.

A good flute is laid in only two passes: one down each side. Study the Gothic gauntlets in Figure 16.14—the even hammer strokes on the outside are mirrored by even lines made by the creasing stake on the inside.

The size of the flute is dependent upon two factors: the angle at which the piece is held (a sharper angle results in a steeper flute) and the surface area of the hammer that touches the flute (I try to use only a third or so of the hammer—roughly 5/16 inch). More surface area will equal a bigger flute. Most novice or intermediate armourers produce flutes that are too flat and much too large. Medieval flutes—especially during the 15th century—were often very steep in terms of their angle and very small in terms of their height (usually 1/4 to 5/16 inch). On chamfrons and other specialty items they were sometimes larger, but this does not seem to have been the norm.

Laying flutes close together should present no special problem if the armourer is already achieving consistent results. As can be seen in Figure 16.15, the top edge of the hammer is the portion that does all the work. When the flutes are close the only risk is that an errant hammer stroke will ruin an adjacent flute—a real risk if you aren't consistent but not much of a threat if you are. Take special care not to rush when the flutes are close since it is disheartening to ruin a piece near the end of a complex project.

Some modern armourers use swedges either to rough their flutes or as a final fluting solution. This definitely speeds up production, but an unsharpened, round flute looks funny on a supposedly Gothic piece, so take care to make the appropriate flute for the period you are recreating.

Finishing the flute is a gentle challenge. The sanding phase must be done such that the edge of the sanding medium does not cut into the base or sides of the flutes. Sanding only with a 100 grit or finer belt or wheel will help, but nothing can take the place of caution and care. Don't rush and you stand a far better chance of success.

ROLLING EDGES

Rolled edges are the main way that plates are strengthened through hammerwork. They

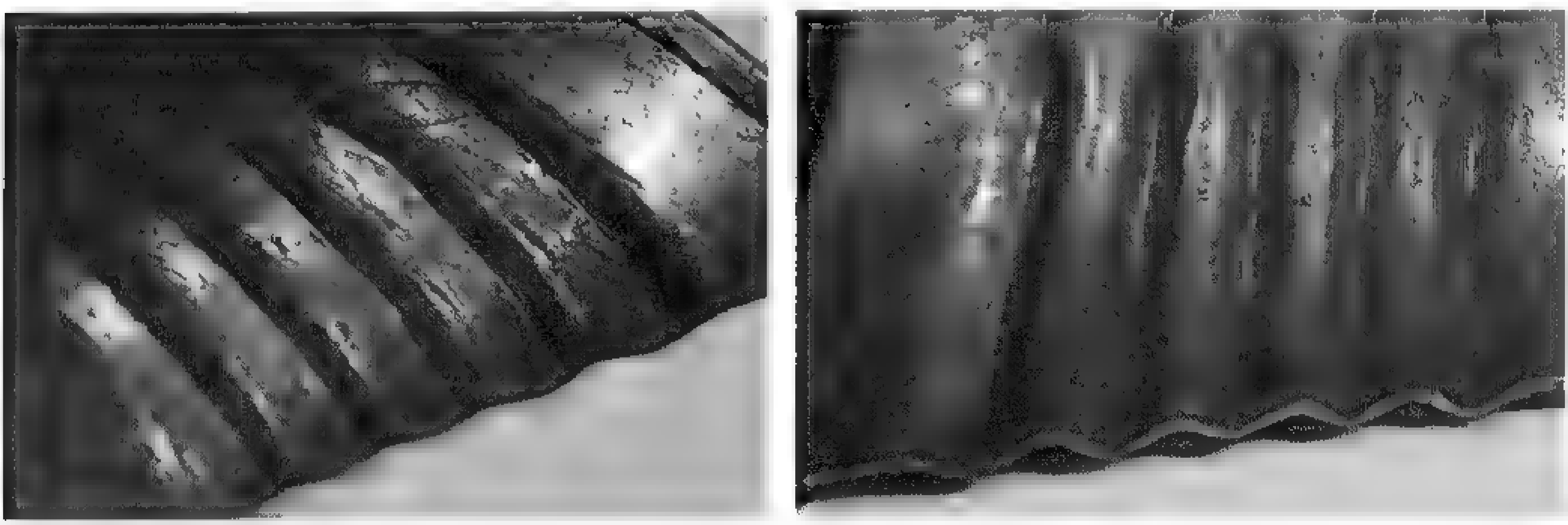


Figure 16.14 Closely laid fluting on a German Gothic gauntlet, c. 1490, by the author. These flutes were laid in one pass each from the outside over a creasing stake. From the underside it is evident how clean a flute should look when the technique has been mastered. Fluting takes practice, but once the angles and a consistent hammer stroke is developed, it is not difficult.

Figure 16.15 (above and right). The setup shown here is not very different from that required for embossing, though the angles are slightly different and only the toe of the hammer face is used. During the fluting process, the piece must be held at a consistent angle and the hammer blows must be of consistent force and placement in relation to the stake or else a wavy appearance will result—which cannot be removed. Clean fluting only requires two passes: one on each side of the flute.

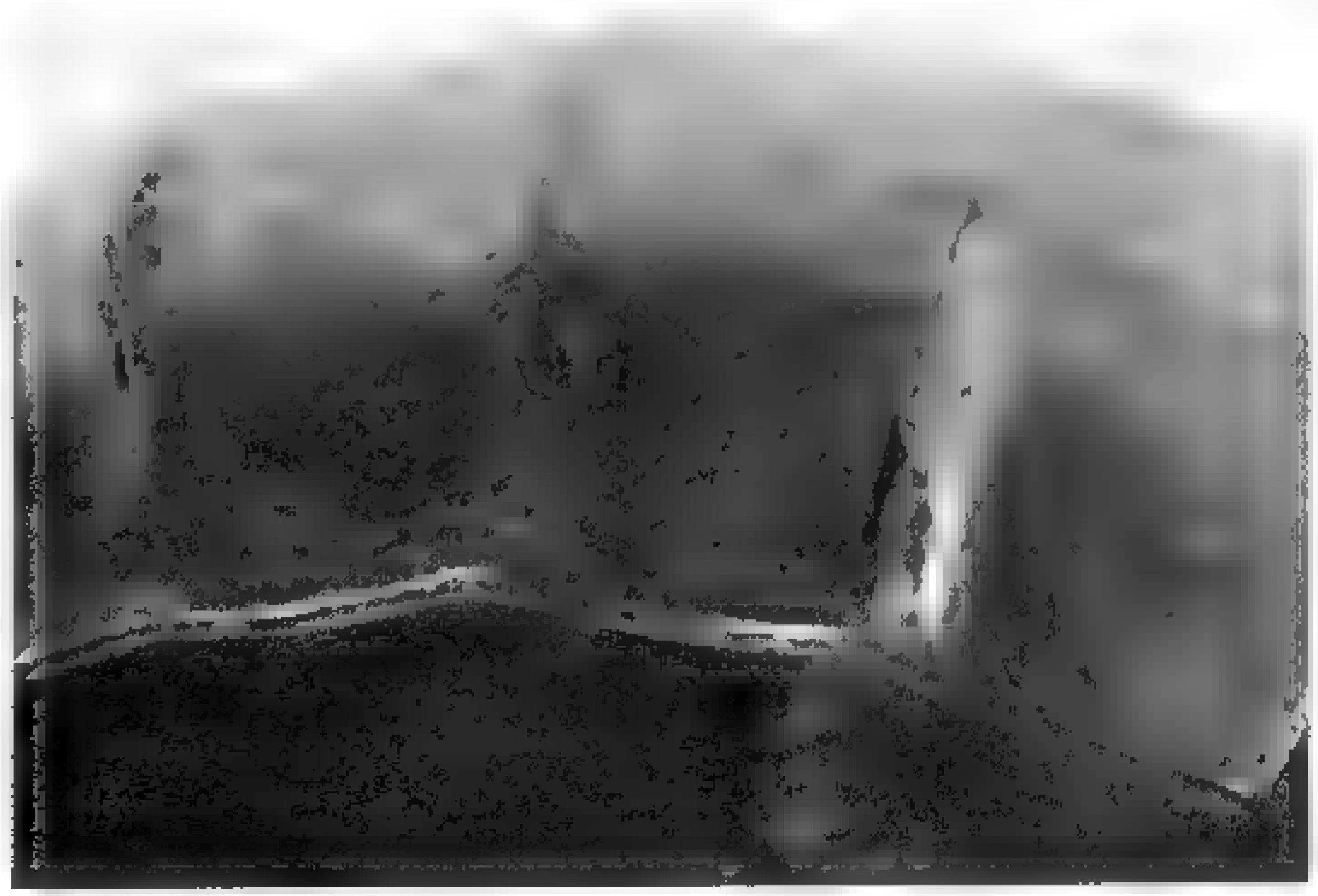


Figure 16.16 (above and left). Flutes roughed into a piece from the front and back.

are especially appropriate at the tops of cuisses, the arm and neck holes of cuirasses, and on some gauntlet cuffs because they help prevent the plate's edge from digging into the wearer.

During the 14th century rolls were not applied universally. When they did appear, they were generally rolled toward the outside rather than turned toward the inside as they tended to be in the early 16th century, though the armourer should look carefully at the historical models that apply to his project.

Rolls in the 14th Century

Rolls during the 14th century were rarely if ever applied to bascinets—neither visors nor the bottom edges on existing helmets feature any rolled edges, their strength coming more from their mass. Helms sometimes had the bottom edge rolled, occasionally to the inside. Brigandine plates did not seem to have been rolled at all, while the breastplates popular late in the century generally featured modest rolls at the neck and arm openings. All extant examples also have a roll all along the bottom edge. No spaulders survive from the period, unfortunately, though there is neither reason nor evidence for rolls being used on shoulder defenses. Arm harnesses generally featured rolls at the wrist openings, and they were optionally applied at the inside elbow openings of the vambrace (and potentially the rerebrace as well). While no surviving gauntlets show a rolled edge, it might be conceivably used at the cuff opening. Legharnesses were not always reinforced with rolls, though they are appropriate at the top of the cuisse and sometimes at the ankle opening on greaves.

Figure 16 17 A finished rolled edge

During the bulk of the 14th century, edge-rolling seems to have been restricted to small and medium rolls, some done "free form" and others done over a wire. During the 15th century the size of these rolls was substantially increased, also increasing their difficulty in terms of technique and the effectiveness of the roll as a kind of integral stop-rib capable of deflecting a blade, arrow, or lance point and redirecting it away from the body.

Technique

For a small roll as is used on an arm harness or gauntlet cuff, only 3/8 inch or so of metal is required. I have done rolls for Gothic gauntlets that require as little as 1/4 inch, but remember that the metal will roll completely around in a circle, so you will need roughly three times the width or height of the roll to allow sufficient metal for it. Sometimes on cuisse uppers the roll can be quite large; I have sometimes left as much as 2 1/2 inches of material for a particularly large roll, but this is unusual. Normal rolls as found on breastplate openings and cuisse uppers are usually in the 5/8 to 1 inch range. Note that normally rolls are not placed on spaulders from the 14th century, although the last lame is often rolled

in the 15th. Likewise demi-greaves are rarely if ever rolled; generally they are flared to match with the greave instead.

An edge can be rolled to form a flat, round, triangular, or square roll depending upon the skill of the armourer and the historical requirements for the piece. Round and narrow flat rolls are appropriate for the 14th century; triangular and square rolls do not come into play before 1420 or so. Roped rolls were perhaps done over pitch or lead that was then drained from the roll cavity upon completion, though roping is inappropriate on pieces prior to the 16th century.

The first step is to coax the metal to 90 degrees, usually with a steel forming hammer without sharp edges. Marks should be avoided, as they tend to turn into buckles during the rolling process. I like to lay a sharpened crease to "freeze" the metal into place and to prevent the body of the piece from twisting out of position as the roll is being done. This is particularly problematic at the edges and in the tight turns that are the mark of a truly accomplished armourer. Once it is at 90 degrees, you will either want to use another chisel stake to guide the metal to about 100 degrees or very gently knock the metal over to form the roll or fold.

It is very easy to produce a fold and not too much harder to produce a roll over a wire, but it does require skill to make a large hollow roll that is round in form. Each of these techniques will be covered in turn in the sections that follow.

Making a Narrow Rolled Edge

Narrow rolls, appropriate on arms harnesses, gauntlet cuffs, besagews, and greaves throughout the 14th and 15th centuries, are not difficult but must be done with care. There is a tendency for such rolls to become over-large, an easy mistake since a narrow roll is more difficult than a more generic but less appropriate medium-width roll.

Narrow rolls will end up being 1/4 inch or less in width (some are as narrow as 1/8 inch). Most armourers prefer to lay their rolls with a small square, oval, or rectangular hammer. No special stakes are required; a sharp edge on the side of an anvil, a bichorn, or similar stake will suffice.

For the purposes of this section I will roll the edge on a vambrace wrapper for the arm harness done in Chapter 32. The purpose of this roll is twofold: to strengthen the plate against deformation and to keep the vambrace from digging into the wrist, an important consideration with the tendons and veins present.

Rolls should be started *after* the planishing and initial sanding are done. Since 14th century rolls are generally done toward the outside, there will be no opportunity to finish the piece between the roll and the plate's face, so the sanding must be done in advance.

The roll is first marked on the inside since it will be made to the outside. The middle finger can be used as a guide to make a smooth line paralleling the edge, roughly 5/16 to 3/8 inch from the edge (fig. 16.18). The smaller the line the smaller the roll. Make sure the edge is smooth and even before you start; otherwise the roll will appear uneven and present a hazard while the finger is being run along the edge.

The next step is to hammer the roll to 90 degrees (fig. 16.19). This must be done with great care using a series of small, even hammer strokes. Blows with excessive force will result in wrinkles that are exceptionally difficult to remove.

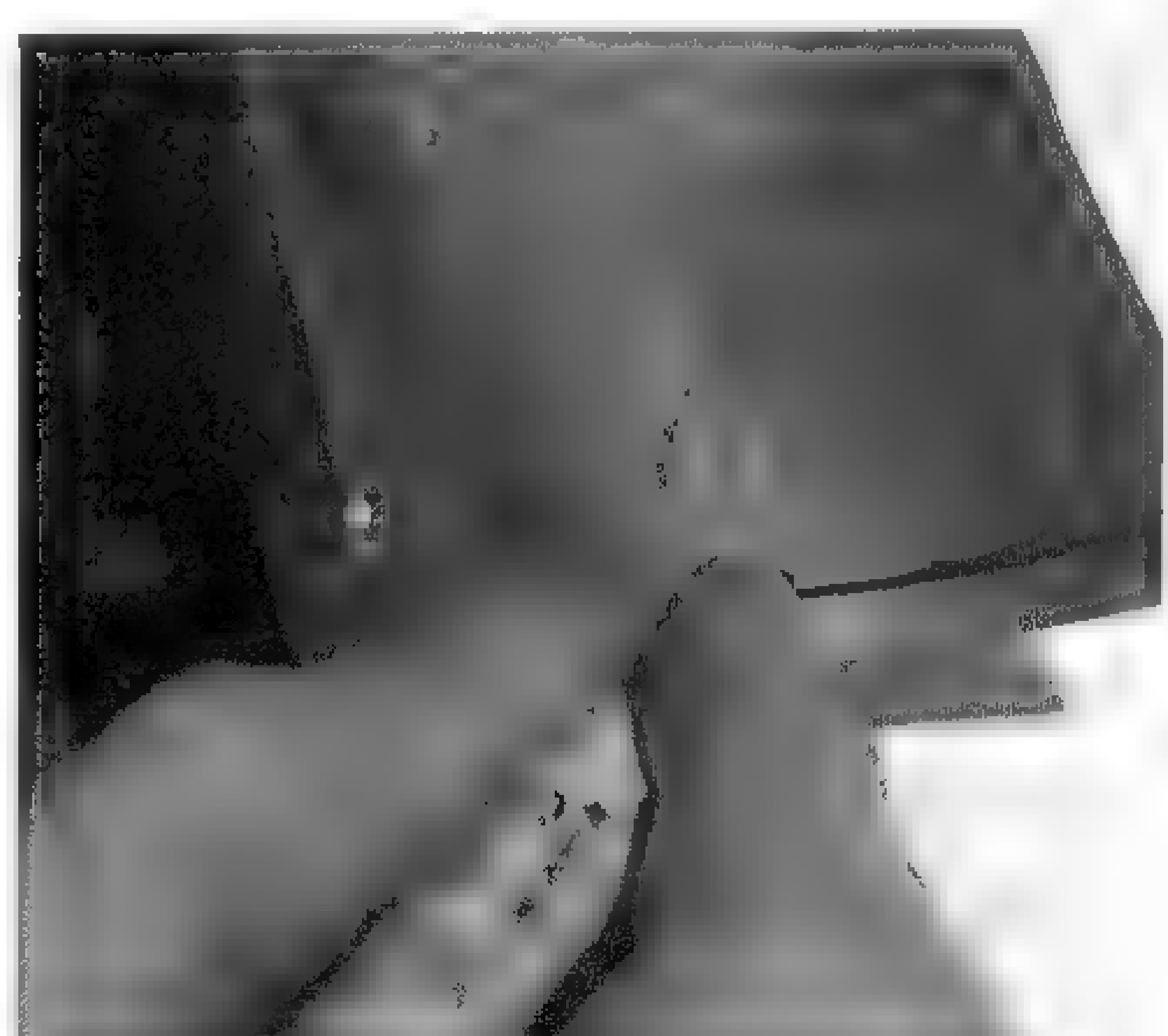


Figure 16.18. Marking a small roll

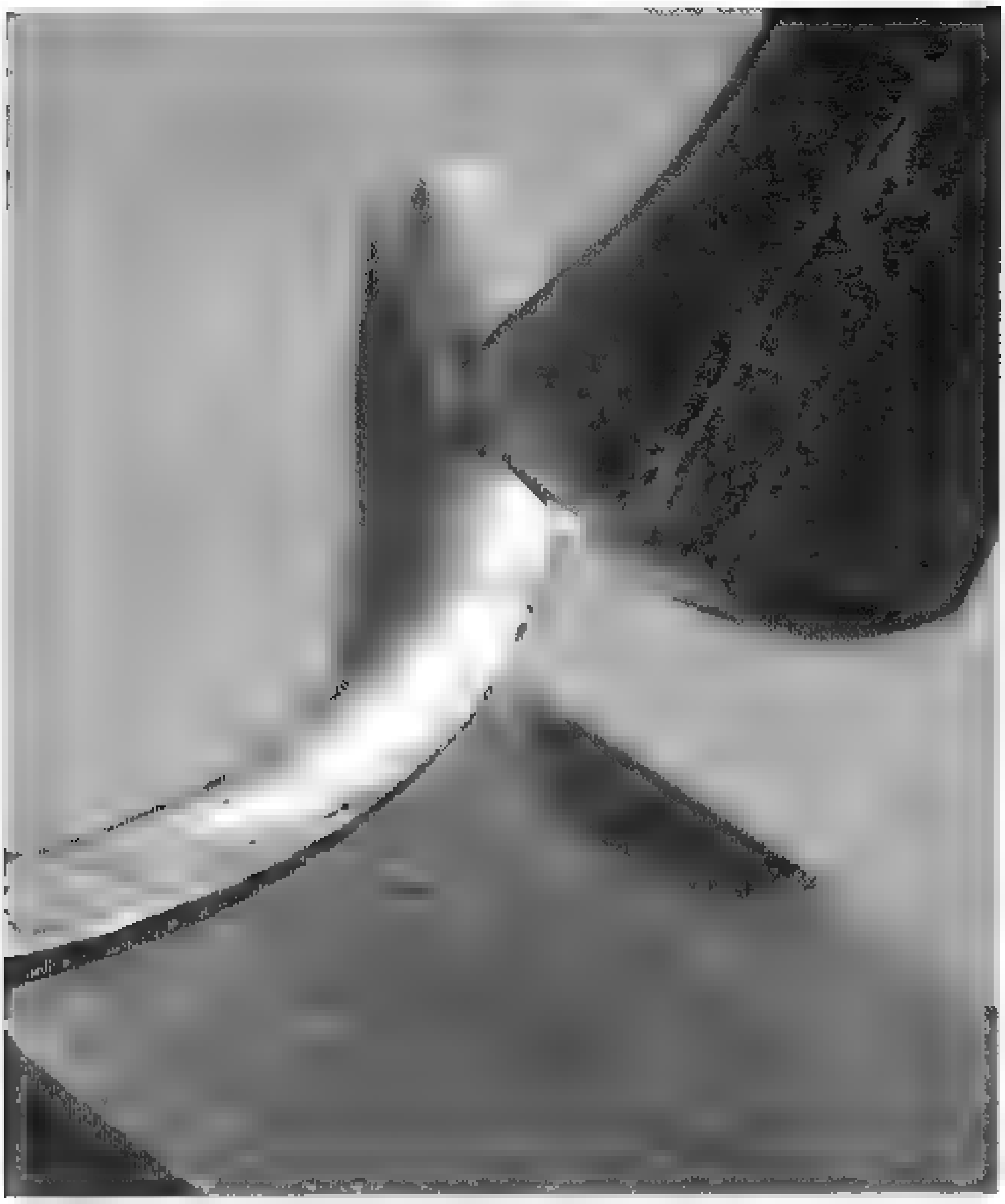


Figure 16.19. The metal is first coaxed to 90 degrees

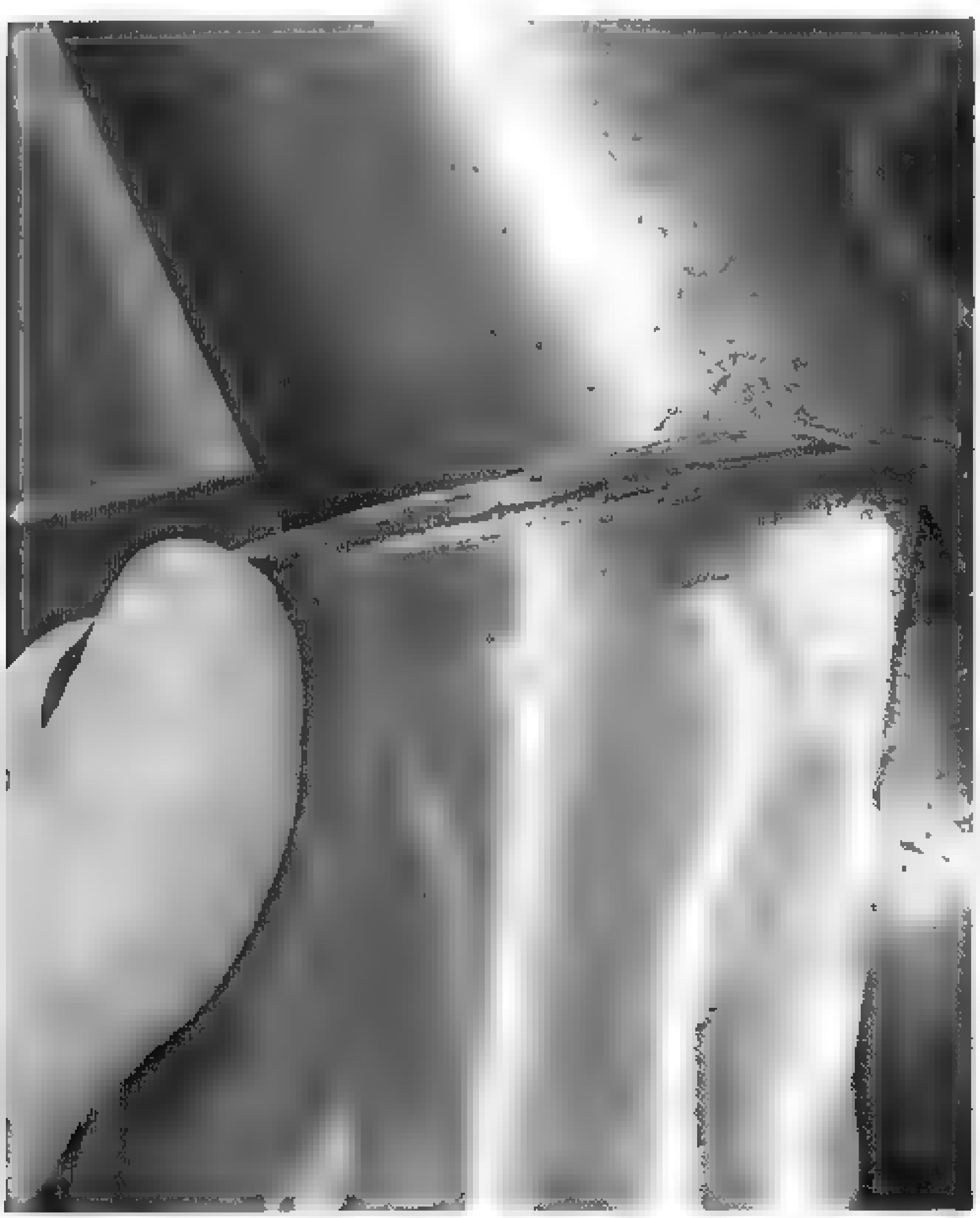


Figure 16.20 Next it is gently turned to a U shape, then sanded to finish the edge before it is closed.

There is a difference of opinion amongst armourers I have spoken with concerning whether or not it is necessary to freeze the roll at this point. Freezing the roll entails sharpening the area along the fold similar to how embossing is done. I have not found it necessary for a roll but have found it useful when executing a small fold.

As the first 90 degrees is made, the hammer should be worked from one side to the other in successive passes without jumping around. While this can be done over any sharp surface, it will be easier if the edge is undercut somewhat to allow for something just over 90 degrees, but this is a luxury rather than a necessity.

Once the roll has been made to 90 degrees, the next step is to curve this edge into a U shape (fig. 16.20). It is important to do this with many small, gentle hammer strokes. Strokes that are too hard can easily crush a small roll, leaving only a more clumsy fold in place of the desired elegance of a roll.

To make the U, work carefully from one side to the other. If done correctly, this step can be done without recourse to multiple passes.

Once the U is complete, the edge should be sanded flat to avoid ripples in the edge of the roll. For the next step, the piece must be lifted and the roll gently closed with the upper edge of the hammer face. Be very gentle at this point; exuberance can result in ugly divots that are impossible to remove.

The resulting roll needs to be even, although minor imperfections in its face can be sanded away. Some of the imperfections will be lost in the subsequent polish.

Making a Medium Rolled Edge Around a Wire

As I mentioned earlier, sometimes heaulms from the 14th century have rolls done to the inside rather than the more common roll to the outside. They are made by rolling them around a wire to provide both additional strength and a guide for maintaining the roll's shape and avoiding a less impressive fold. The technique here is substantially the same as it is for a smaller roll, though because of the larger size, more metal must be used, in this case 1/2 to 5/8 inch.

This particular roll is being applied to the lower edge of the great heaulm created in Chapter 30, although such rolls might also be appropriate for those used on breastplates and the upper edges of a cuisse.

In tapping the roll to 90 degrees, it is easy to strike with too much force and end up with an unsightly divot. For this reason it is convenient for the novice to work on rolls that will be turned to the inside where appropriate so any such divots will be hidden. Again, patience is the most important quality for making these rolls work—be careful to work from side to side and bring the metal along gently from one edge to the other.

Once the roll is in the U shape, a 12 gauge wire is inserted and held in place with the fingers. Close the very end of the roll around the wire (fig. 16.23d) and then progress along the roll until it is completely closed.

One benefit to using a wire is that the resulting finish is very smooth, and the risk of creating unwanted divots is vastly reduced (fig. 16.24a). From the outside the edge is smooth, and indeed when the roll is done to the inside, as it is on the lower edge of this great helmet, it is nearly invisible (fig. 16.24b).

Making a Large Rolled Edge

The most difficult rolls are large turns done without the benefit of an underlying supporting wire. Such rolls add a great deal of rigidity and elegance to breastplates and cuisses.

Large rolls require a surprising amount of metal. In this case, the roll is more than 1 1/4 inch at its widest point, tapering to 5/8 of an inch near the inside of the thigh.

Large rolls require exactly the same tools as small rolls, but they require considerably more patience, and even hammerwork is even more important. This section features a thigh roll on a cuisse shaped for the leg harness demonstrated in Chapter 34.

In principle, the steps are the same as those for the small and medium rolls. After marking (fig. 16.25a), the roll is first brought to the 90 degree point. For a round roll like the one featured here, I prefer to use a rounded edge rather than a sharp one in order to start the rounded shape (fig 16.25b). Once again, patience and even hammerwork is imperative.

Once the 90 degree point has been reached, the edge should be carefully evened through sanding. If this is not done the roll can be very rough. The overall crispness of line is crucial at this stage (fig. 16.26a).

As with the smaller roll, a U shape is achieved next (fig. 16.26b). At this point there is a danger of flattening the whole roll, which could be a complete disaster. Do not rush the process or you will end up with folds and ripples that can quickly destroy the final product. Unfortunately, this often happens when the cuisse or breastplate is near completion, so such a mistake can be very

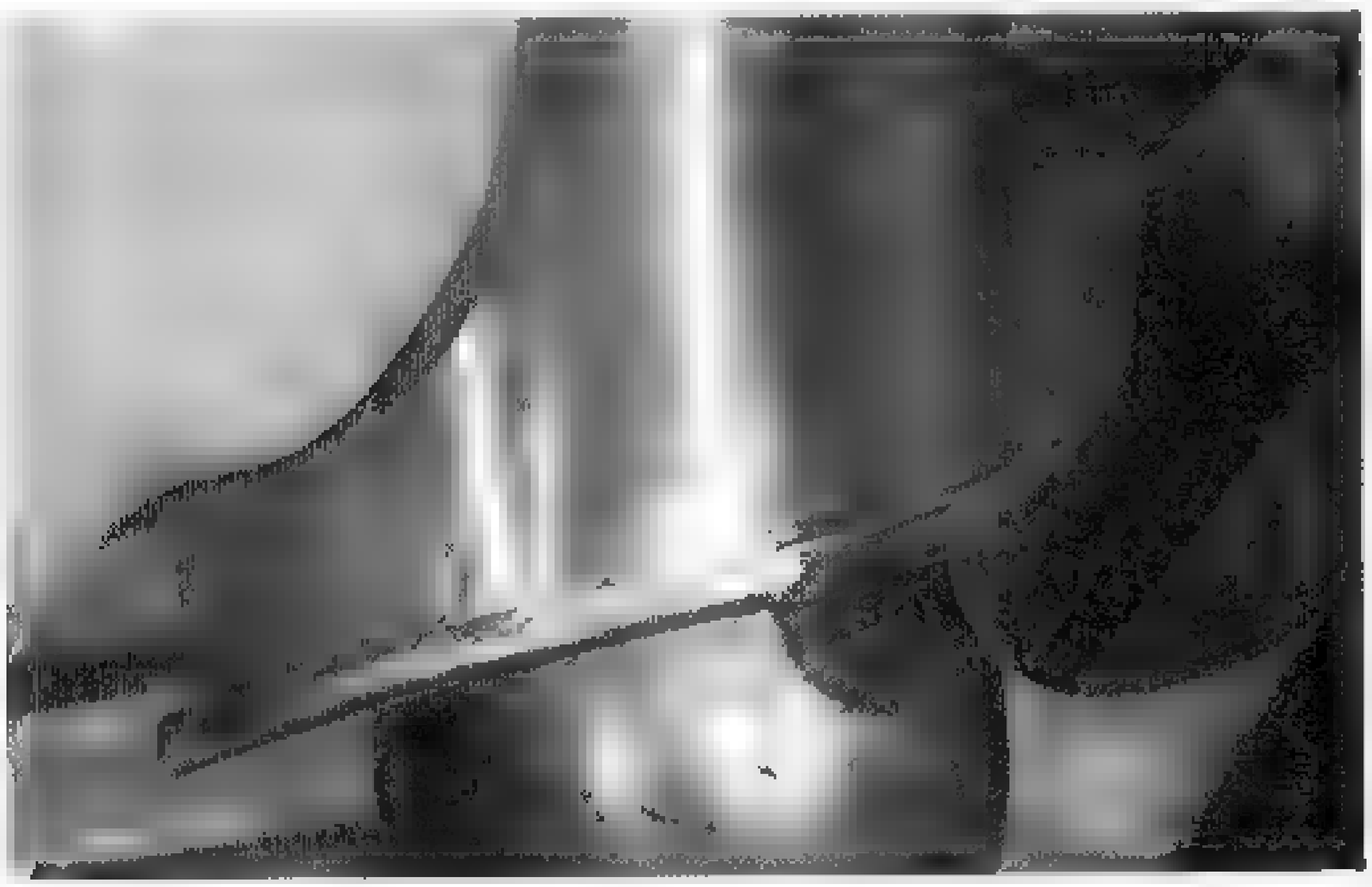


Figure 16.21 Holding the work up from the stake, the edge is coaxed over the toe of the hammer. Do not rush or wrinkles will appear and ruin the effect

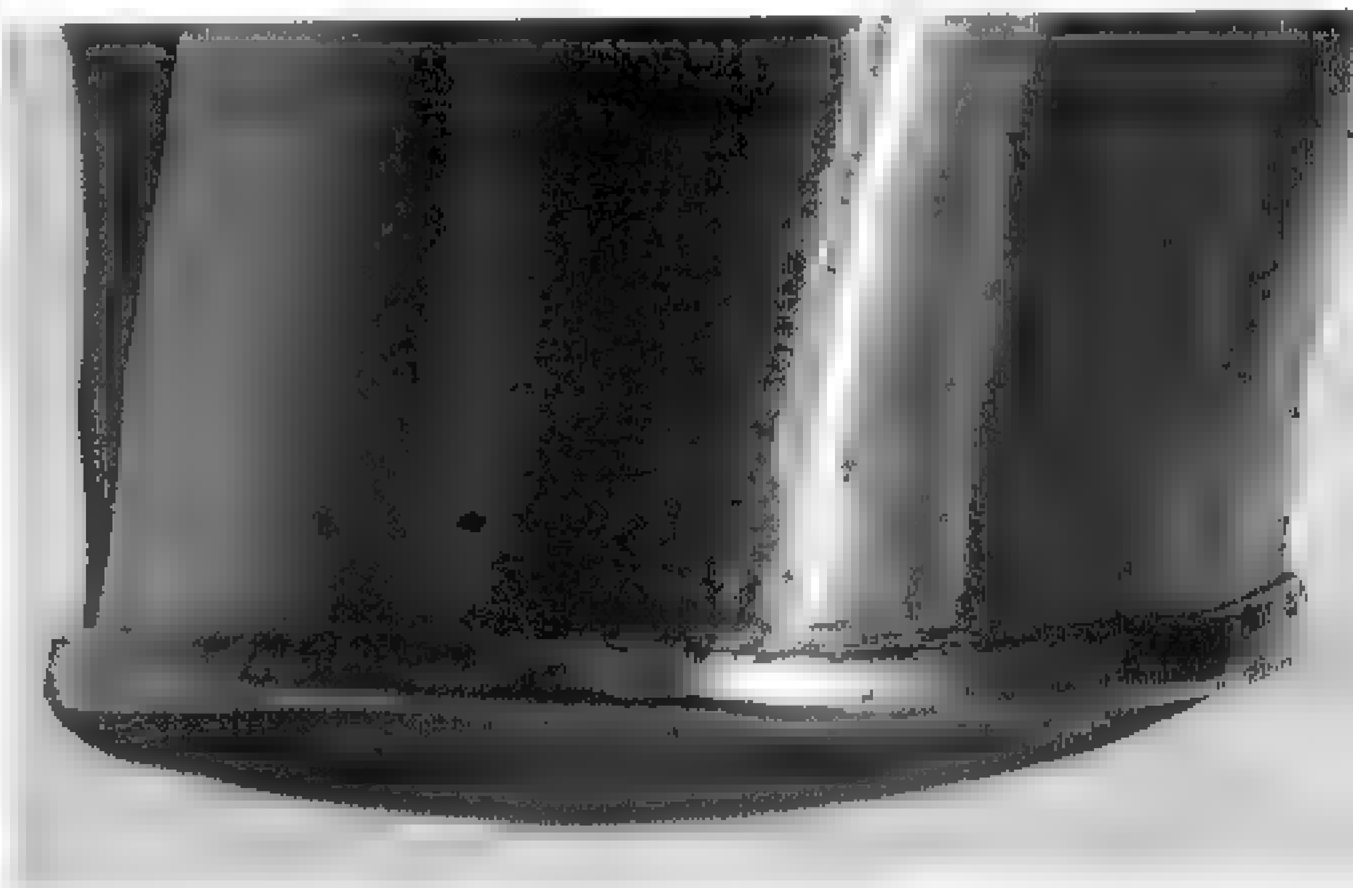


Figure 16.22. A finished small roll ready for sanding

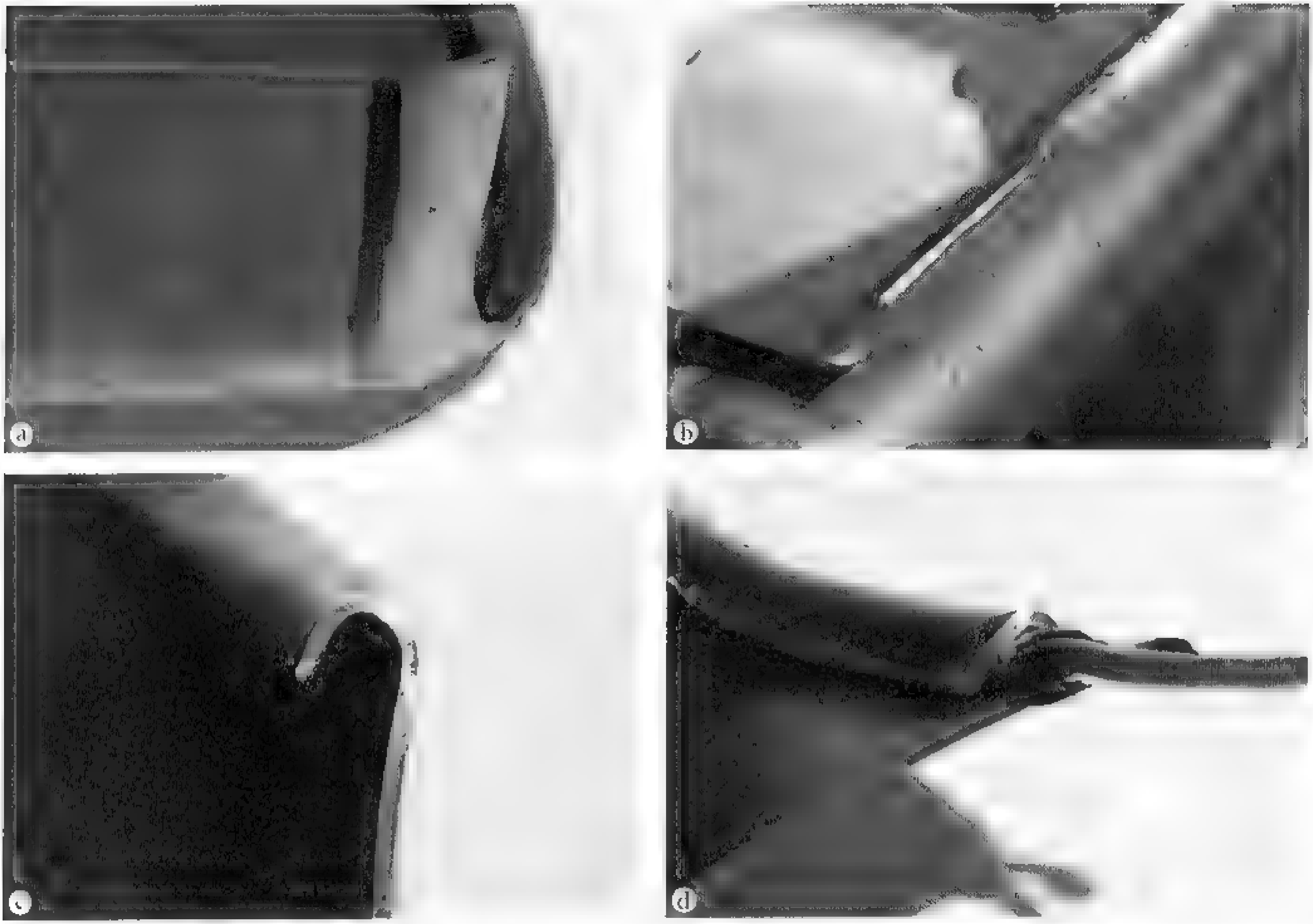


Figure 16.23. Making a medium rolled edge around a wire

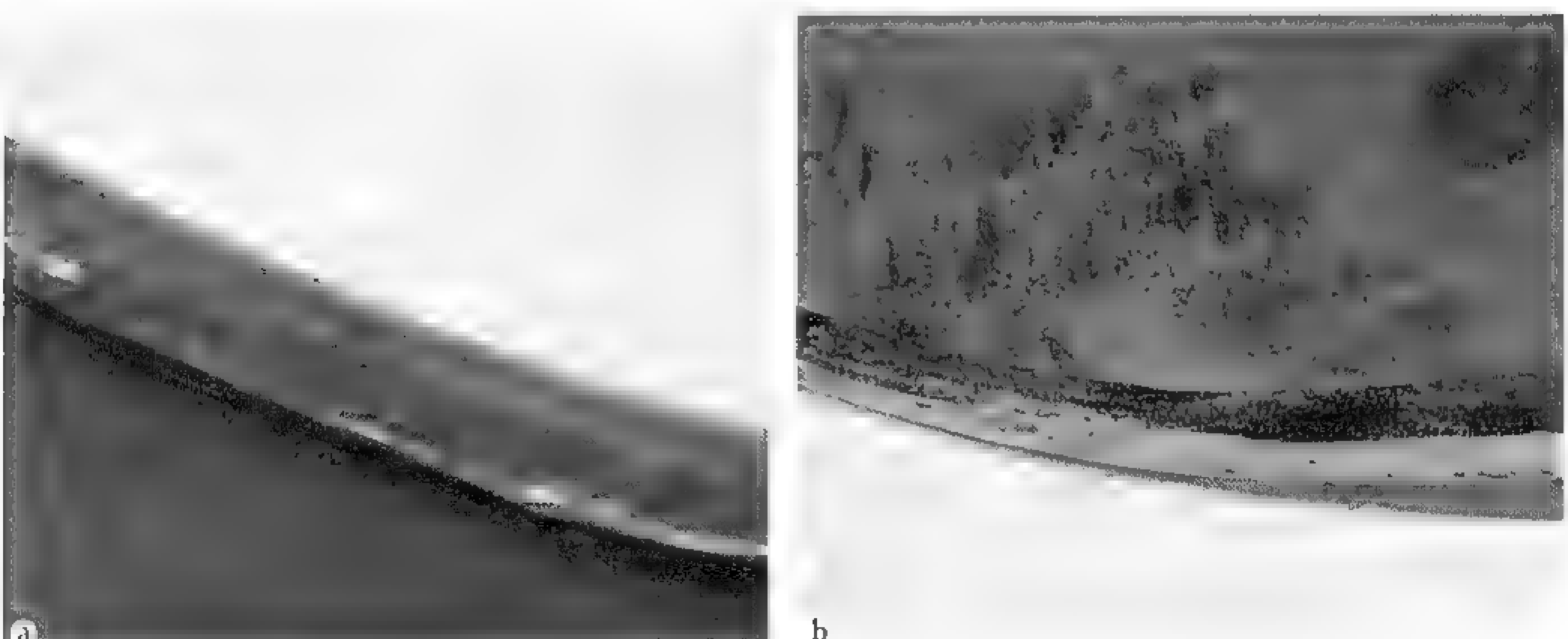


Figure 16.24. The edge just prior to the final pass and, right, the finished roll from the outside, mostly invisible

costly. Be patient and protect your previous time investment.

To close a large roll, the angle of the plate is important. Some armourers do this with a large rawhide, but I prefer the control I get with an oval or rectangular forming hammer; the steel-on-steel contact gives me a better feel for the roll. Be sure to maintain a consistent angle while the roll is being completed (fig. 16.27a). When the closure is complete the roll is gently sanded and finished (fig. 16.27b). Be careful at this point not to dig in the edge of the sanding belt or disk or unsightly sanding lines can mar an otherwise impressive enhancement. The final roll should be smooth and even (fig. 16.28).

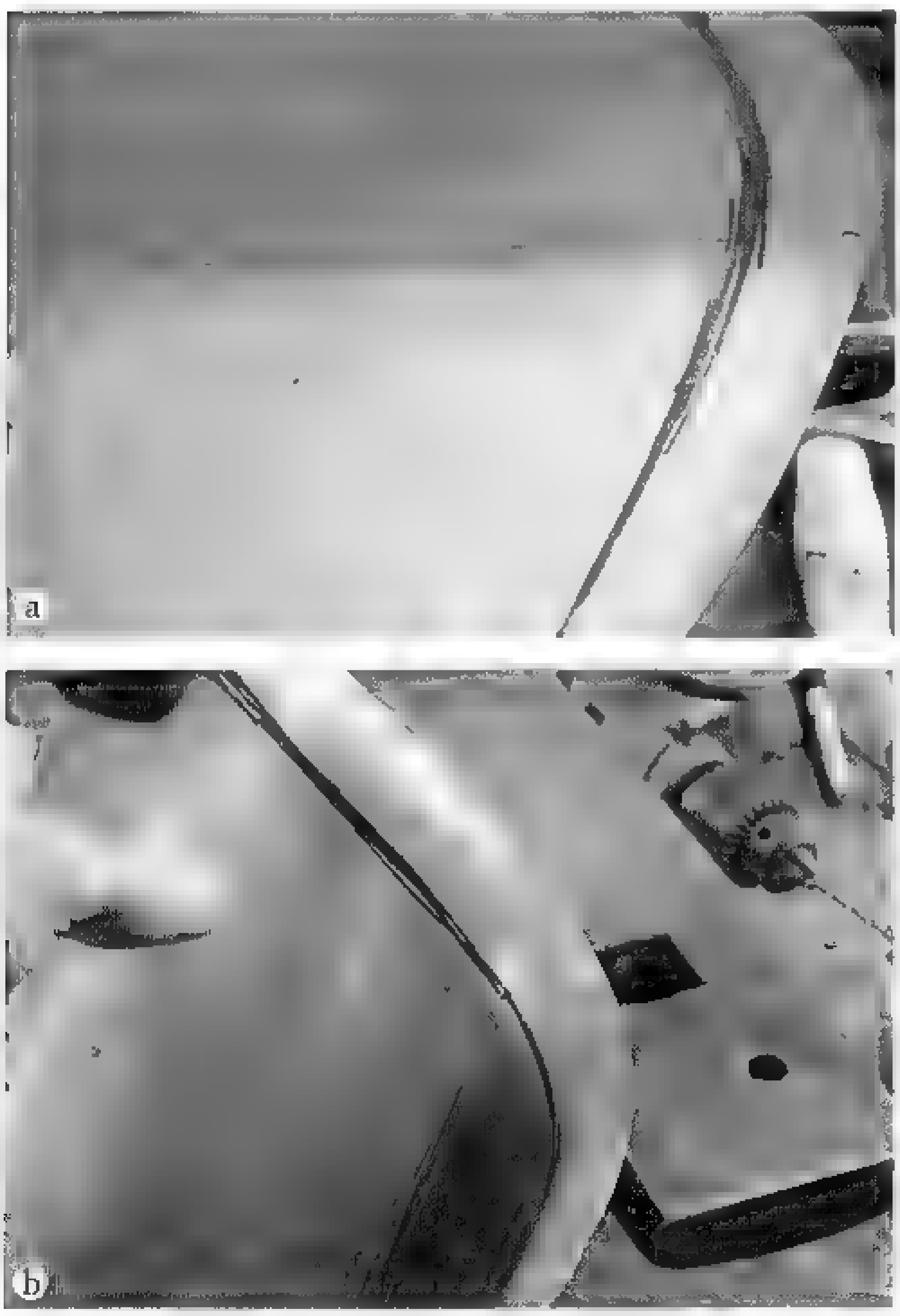


Figure 16.25. After inscribing the guideline, the edge is coaxed to 90 degrees using a softened edge and a generic forming hammer

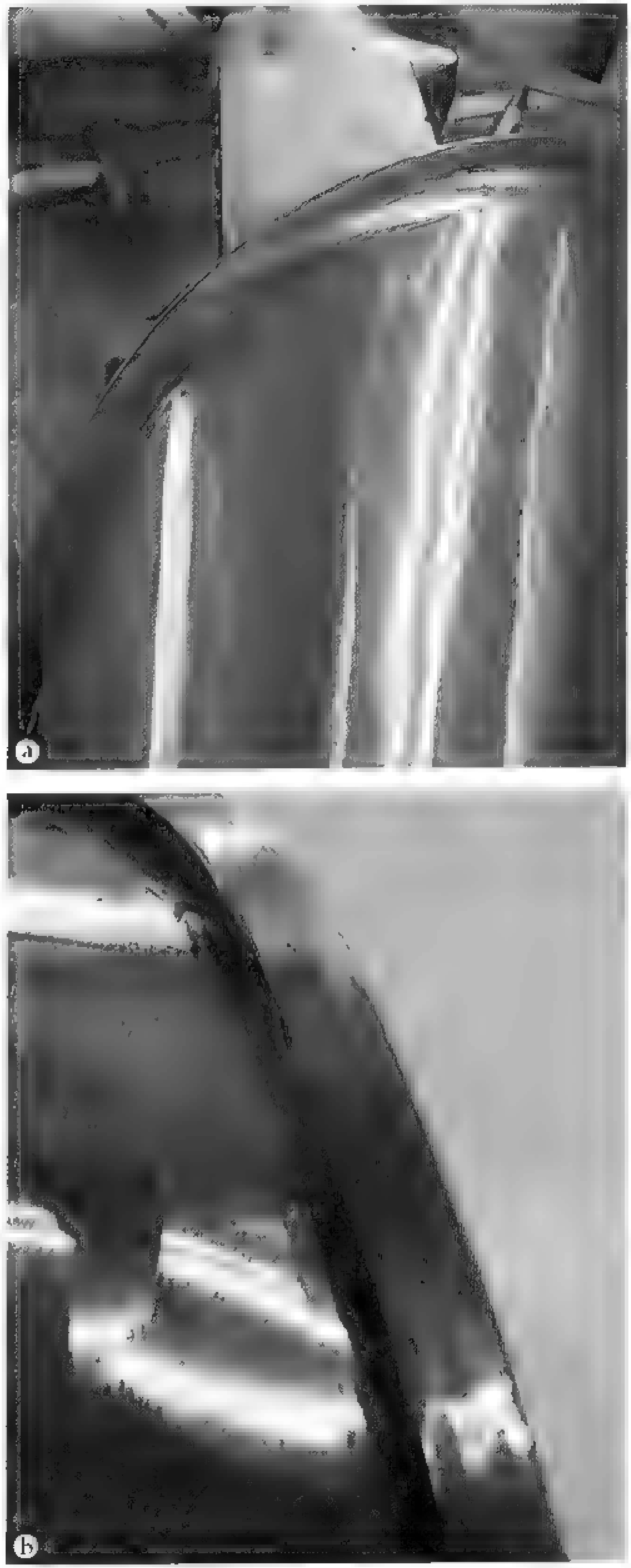
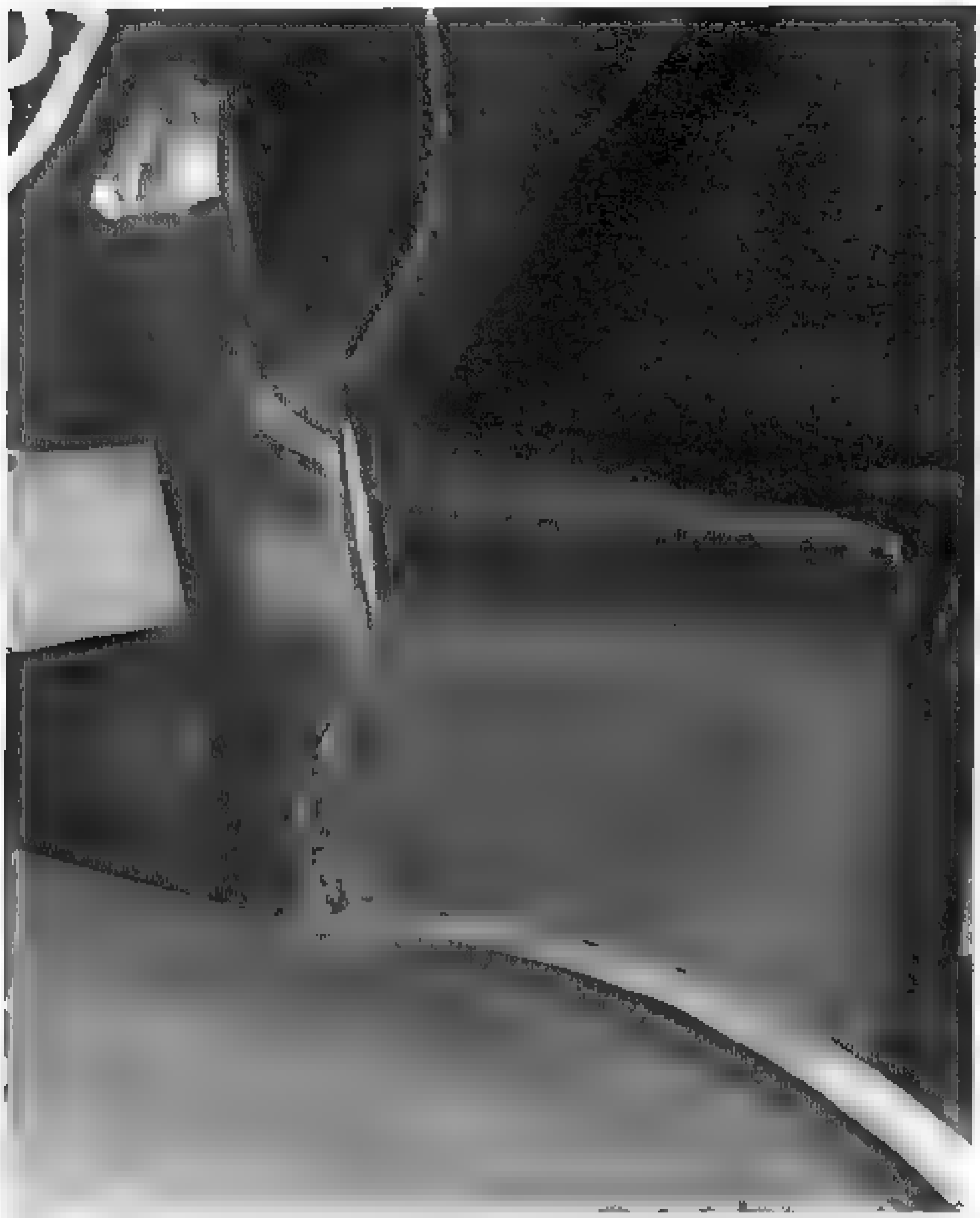


Figure 16.26. Working slowly to avoid wrinkles, the metal is turned to the U shape and sanded before closing



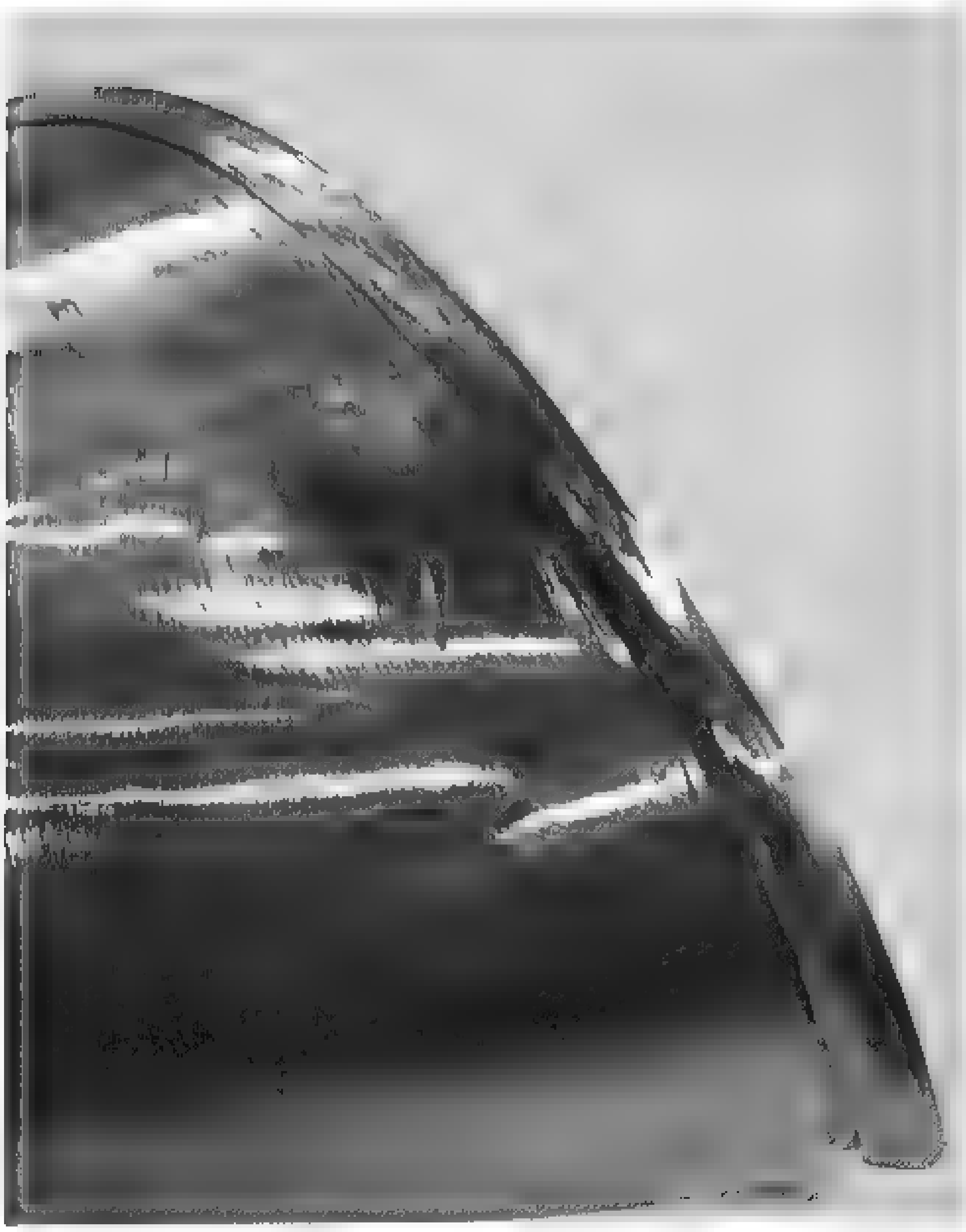
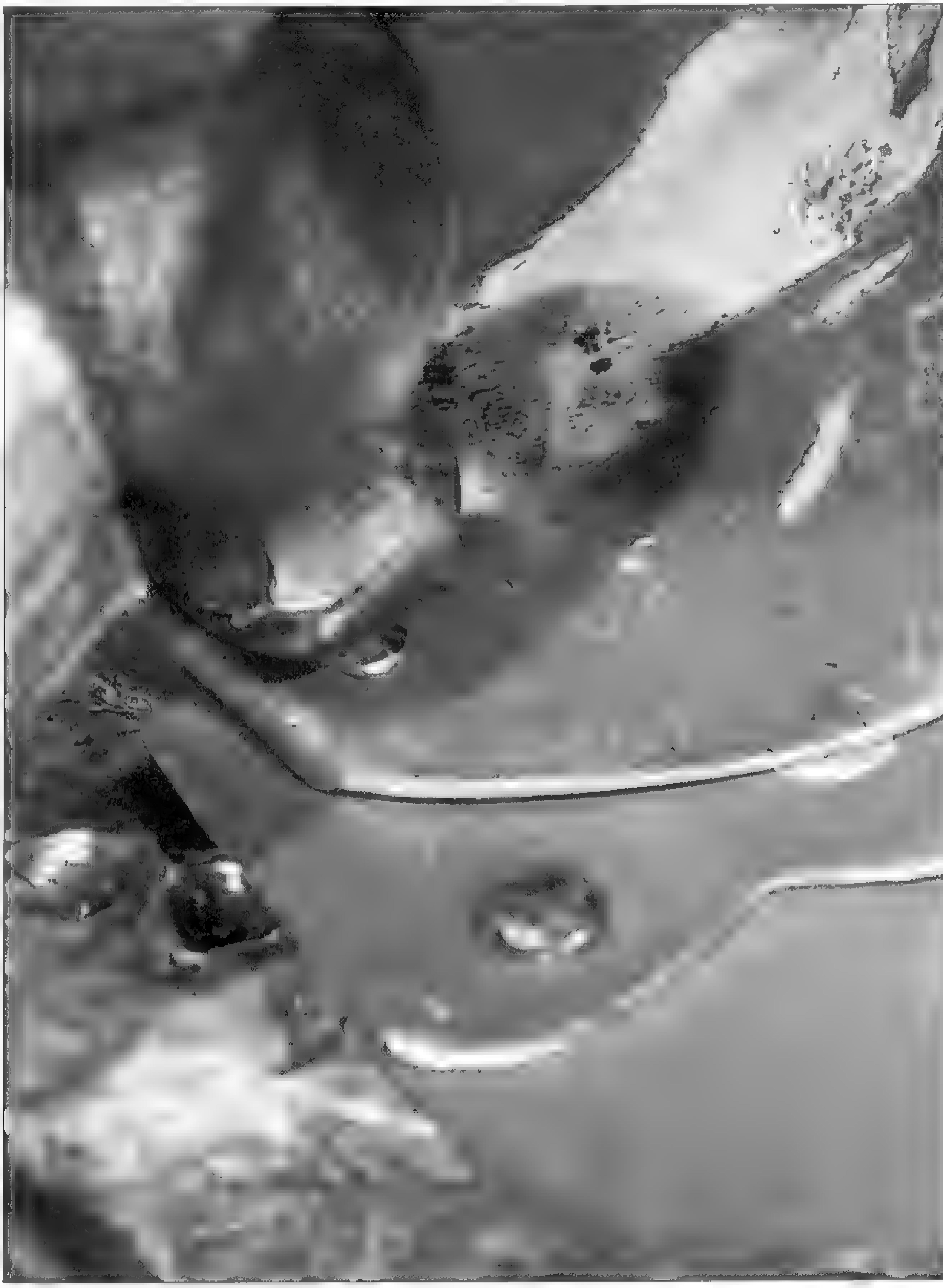


Figure 16.27 Do not get impatient when finishing the roll or all can be lost. After sanding, gently close the roll.

Figure 16.28. A finished roll



Chapter 17

Riveting and Welding

As long as plates have been combined for defense, they have been riveted or welded together. Rivets, often referred to in medieval inventories as "arming nayles," have not changed appreciably in the thousand or so years that they have been used.

Rivets or arming nails are used to affix plates to plates, plates to leather, or leather to leather. Plate-to-plate connections can be done with a firm intention, which means the plates should not move relative to one another, or as an articulation pivot, in which case the rivets hold the metal in place but allow two pieces to move in relation to one another.

Alongside this obvious method, recent research has shown that forge-welds were also used to construct helmets, visors, and other deeply raised pieces where the shape could be drawn effectively from a conical shape. One particular helmet is of interest. The Royal Armouries great helmet (fig. 17.2), dating from the third quarter of the 14th century, would appear at first glance to be held together with rivets.[1] However, closer examination reveals that the upper hoop is not formed-riveted but is probably forge-welded together.

Because of the slag inclusions present in iron used by armourers during the medieval period, forge-welding was considerably easier than it is with modern steels

Opposite page
Figure 17.1. Riveted joints, either metal to metal or metal to leather form a critical component of a harness's mobility and structure. Rivets hold plates securely or provide for movement, depending on how they are set

Figure 17.2. This late 14th century great helm now in the Royal Armouries shows how rivets and forge-welds were used, sometimes combined on the same piece. The top plate is raised in one piece but the second and third are probably forge-welded, while each resulting "hoop" is riveted together. (Photo © Board of Trustees of the Royal Armouries, IV600.)

because the slag acts as a kind of flux that reduces unwanted oxidation.[2]

Accomplishing a forge-weld is both tool and skill intensive, as it requires a forge, anvil, appropriate hammers, tongs, flux, and most importantly, experience. Forge-welding experiments with modern low-carbon steels have produced little in the way of promising results. Because of this, oxyacetylene or MIG-welding are the most usual choices when plates must be welded even by advanced armourers.

RIVETING

In the riveting process, the rivet's shank is piened over into a mushroom, drawing the rivet head inward and creating tension between the two materials being joined.

To pien any kind of rivet, use a ball-ended hammer such as a ball-pien and strike the rivet on an angle, working completely around the rivet. As the hammer strikes, it will create a mushroom that pulls the rivet through the plates. When the mushroom is mostly set, the hammer is turned and the rivet's dome is finished.

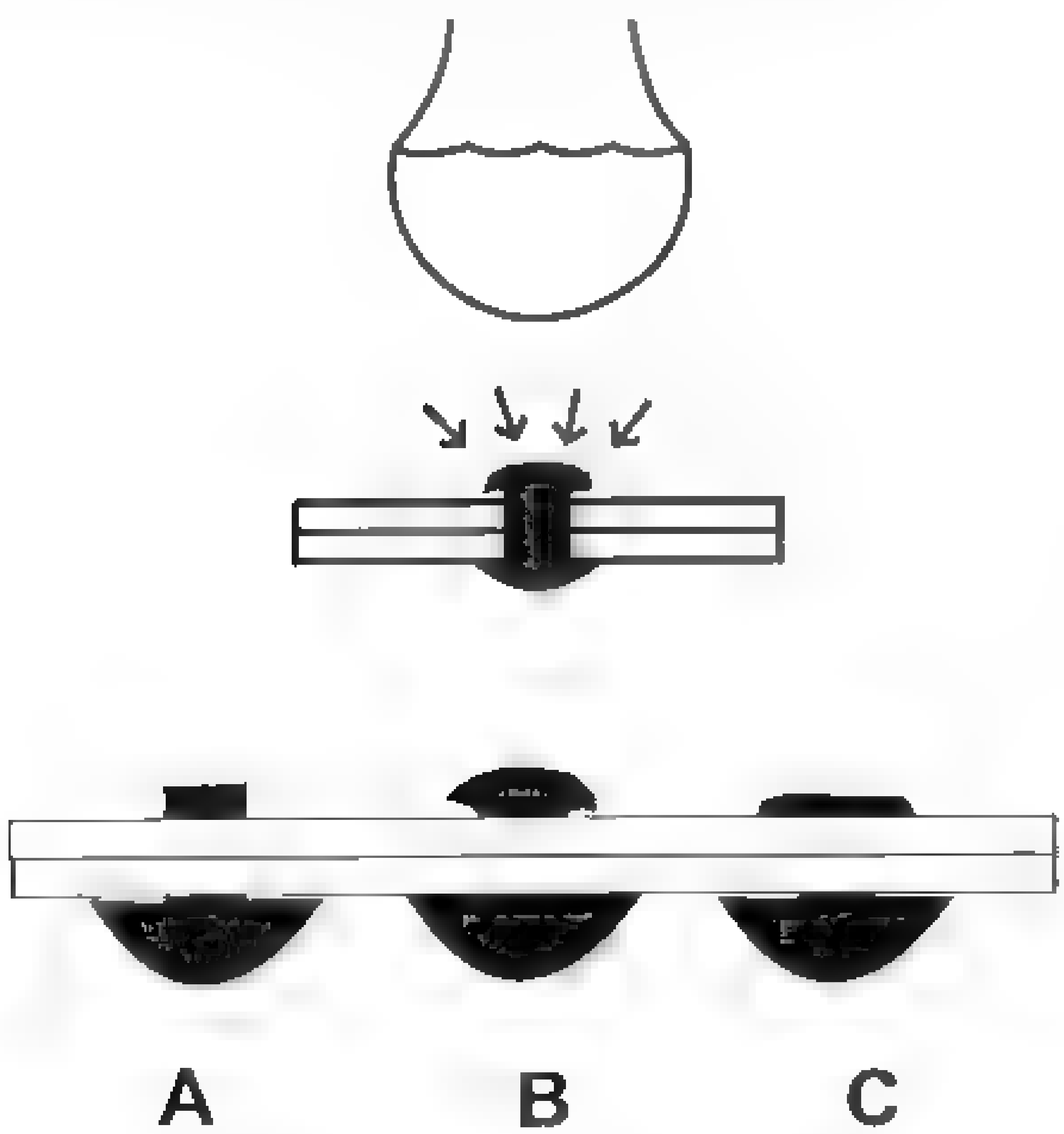


Figure 17.3. A rivet works by mushrooming over the interior head, which in turn draws metal out of the rivet and pulls the two materials together. Using the rounded pien end of the hammer (17.3a), first draw the rivet over into a mushroom (17.3b), proceeding around the rivet. The more aggressive the pien work, the tighter the plates will be drawn together. Finally, use the flat face to even out the facets that result from the piening (17.3c)

Leather-to-Plate Attachment

The armourer must frequently affix a leather strap or lining to a metal plate, as when straps are attached or in the construction of spaulders, early faulds, and munitions arm harnesses from the 15th and 16th centuries. In most cases leather straps on the interior connect plate to plate with an excellent range of movement. Brigandines use cloth or leather as an exterior shell to cover overlapping plates, protecting them from the weather and offering an opportunity for the application of colorful leathers or painted heraldic design.

For leather on the inside of a plate, I tend to recommend the use of an arming nail, though there are certainly historical examples where dome or truss-headed rivets are used instead. In these cases the rivet head remains on the outside plate and the interior is riveted between the strap and a washer. More commonly, however, a wide rivet head remains on the inside of the leather and the rivet itself is piened on the plate's exterior.

The best rivets for this work are common roofing nails. These nails come galvanized, which is bad for authenticity but which approximates the medieval technique of tinning in terms of keeping the nail from rusting, which in turn reduces the wear on the leather. The large, exceptionally thin head makes them ideal for holding leather in place.

Another option is to use 8d box nails, though the heads are not so large and they are more appropriate for use on gauntlets. Still, this is an especially appropriate way to attach strapping, as it is easy to repair in the field and requires neither special tools nor hardware.

To affix leather to a bit of plate, first punch an appropriately sized hole in the plate (fig. 17.4a). If you are using a roofing nail, the punch should be 5/32 inch, while an 8d rivet will require a 1/8 inch punch. A drill can certainly be used, but be careful to deburr the hole completely or it can saw through the leather under combat conditions.

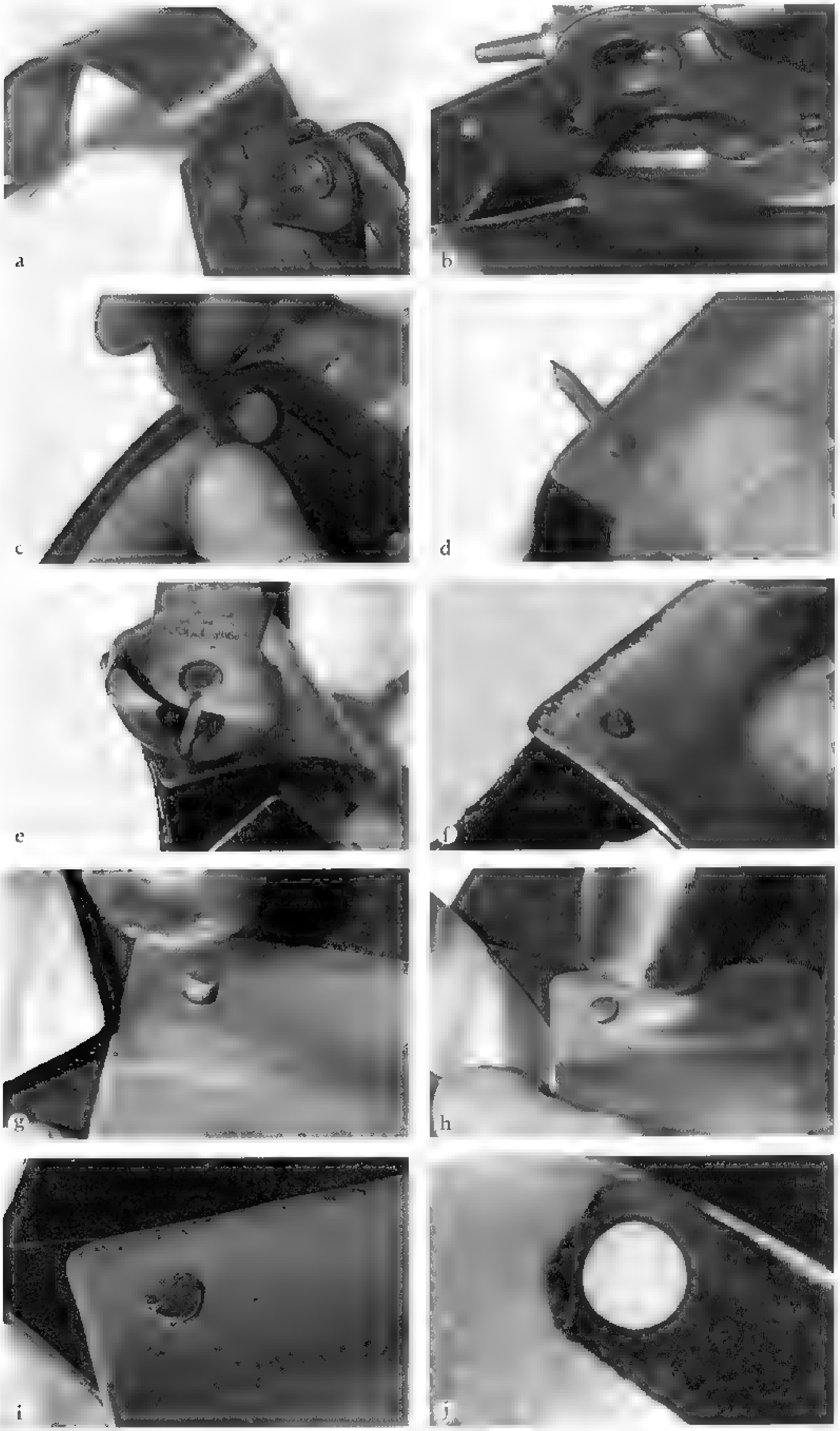


Figure 17 4 Affixing leather to plate using an arming nail

The leather is then marked and punched with a rotary punch (fig. 17.4b). Be aware that the leather may well stretch a bit under wear, so it should be prestretched where possible and some allowance for stretching should be made.

The roofing nail is set from the back side (fig. 17.4c) and pushed through the plate (fig. 17.4d). It is then clipped with a pair of end cutters (fig. 17.4e), leaving approximately 1/16 to 3/32 inch of rivet (fig. 17.4f). The pien face of a ball-pien hammer is first used around the rivet head, pulling the strap snugly against the metal (fig. 17.4g). Finally, the smooth face of the hammer is used to finish the rivet (fig. 17.4h). A completed rivet will be finished in appearance (fig. 17.4i). From the back side, its head will be flush with the leather's surface (fig. 17.4j)

An alternate way to finish an internal leather/steel attachment is to make an "invisible" rivet. To do this, drill a countersink into the metal with a 3/16 inch bit, being careful not to go completely through the plate (fig. 17.5a). Set the rivet as usual, but when it is finished, press the metal neatly into the countersunk hole with the flat face of the hammer (fig. 17.5b).

After the 14th century, straps were frequently attached to the outside of the armour. This was done in one of two ways.

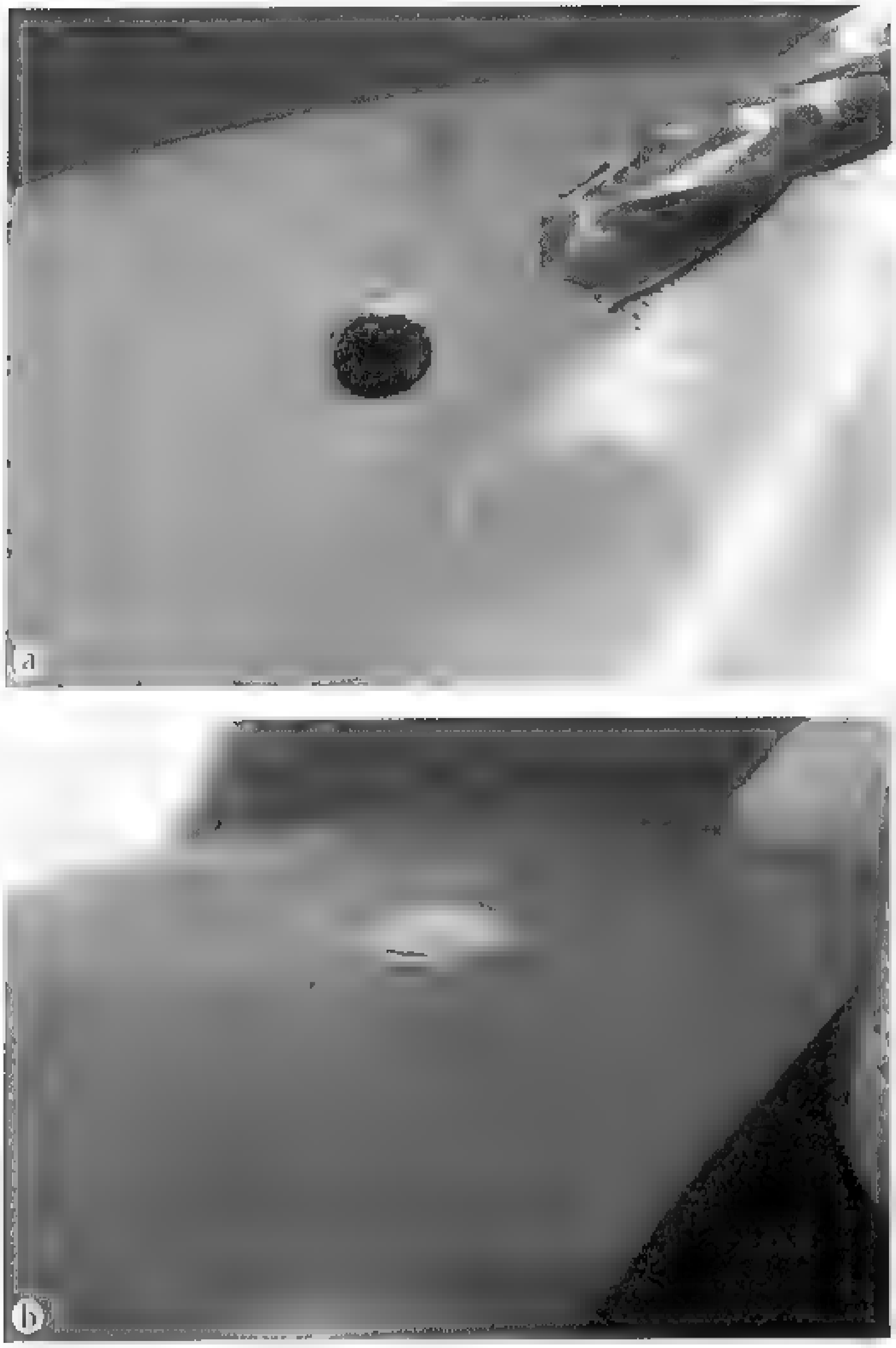


Figure 17.5 Countersinking a rivet

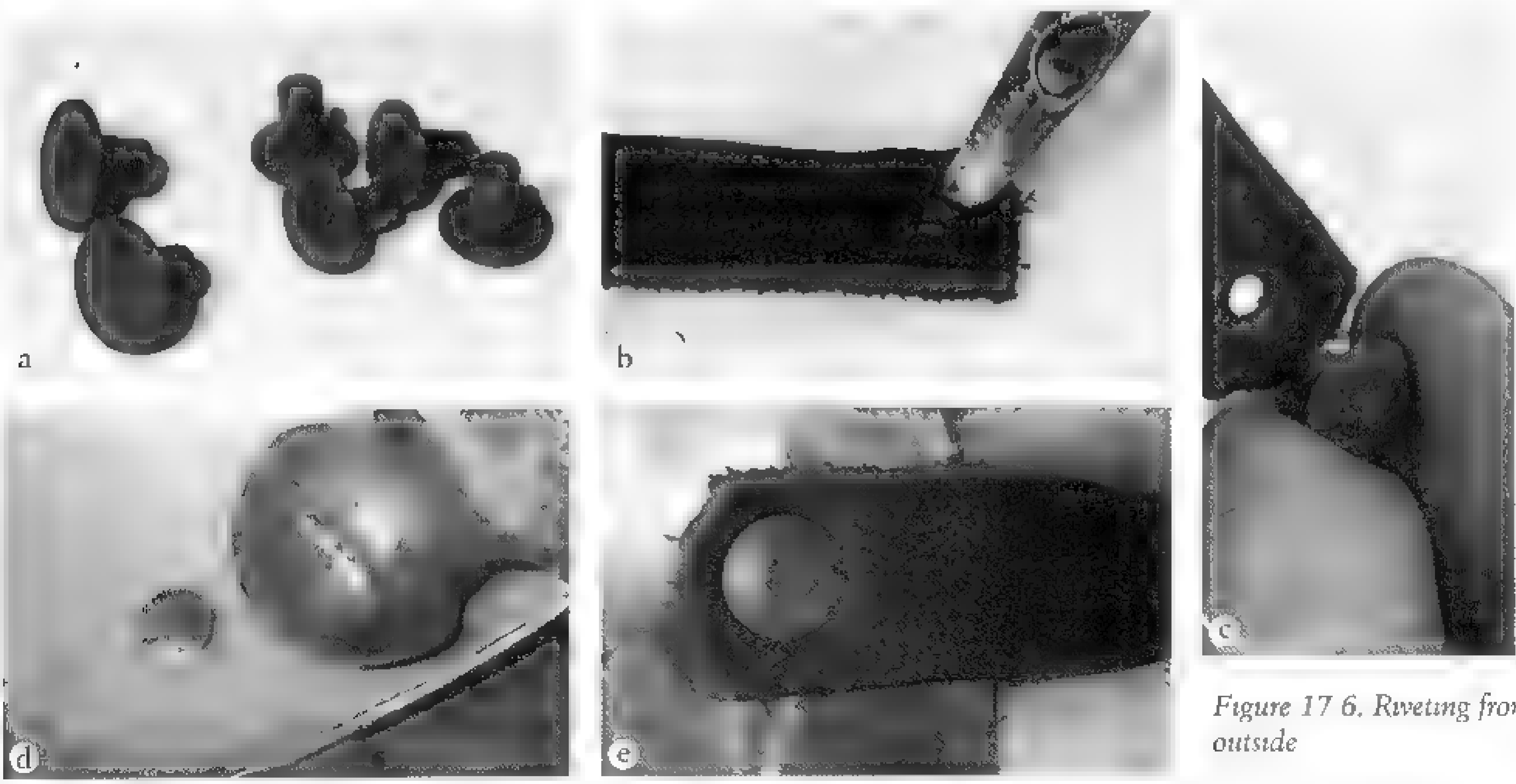


Figure 17.6. Riveting from the outside

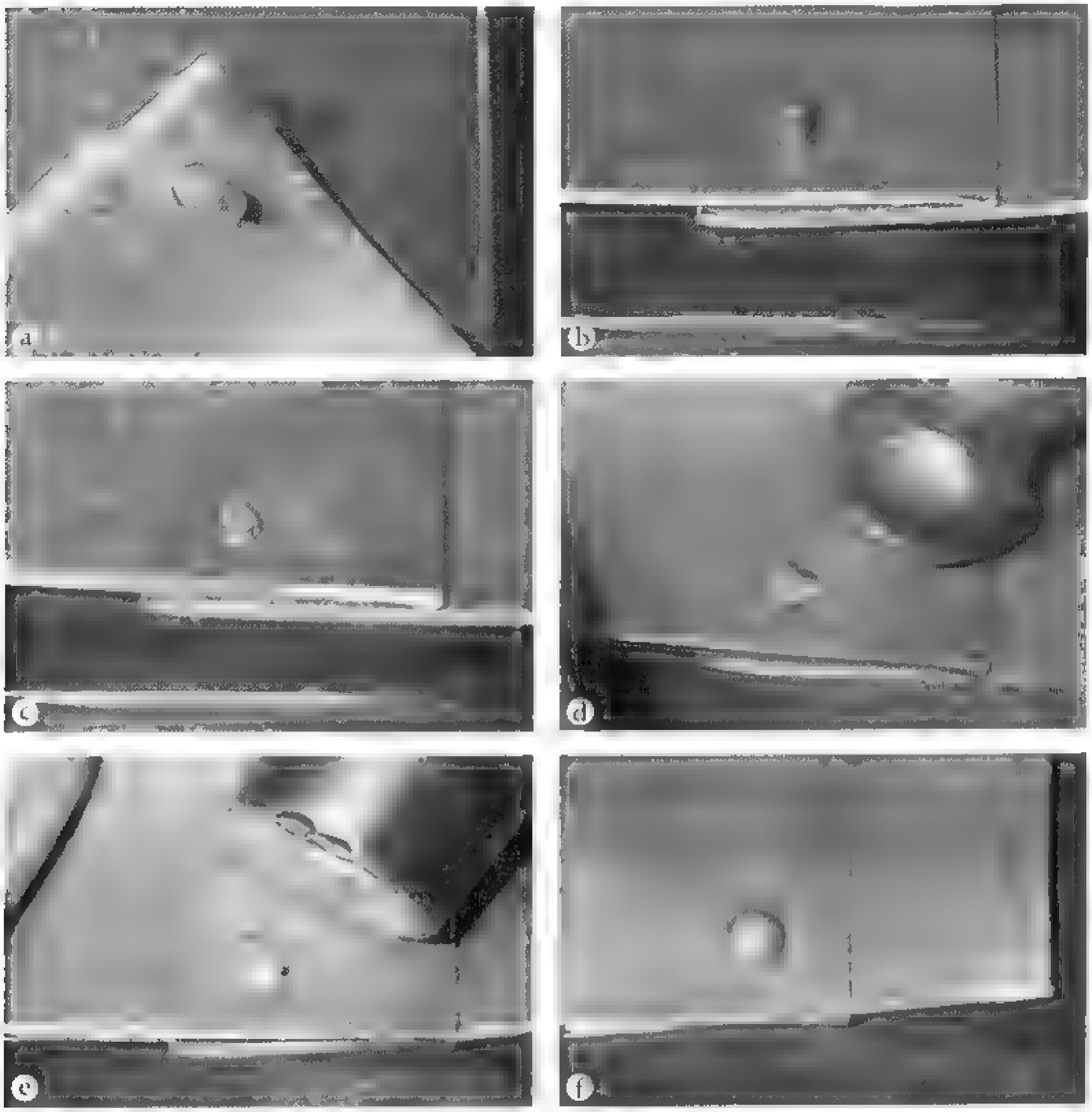


Figure 17.7. Fixed plate riveting

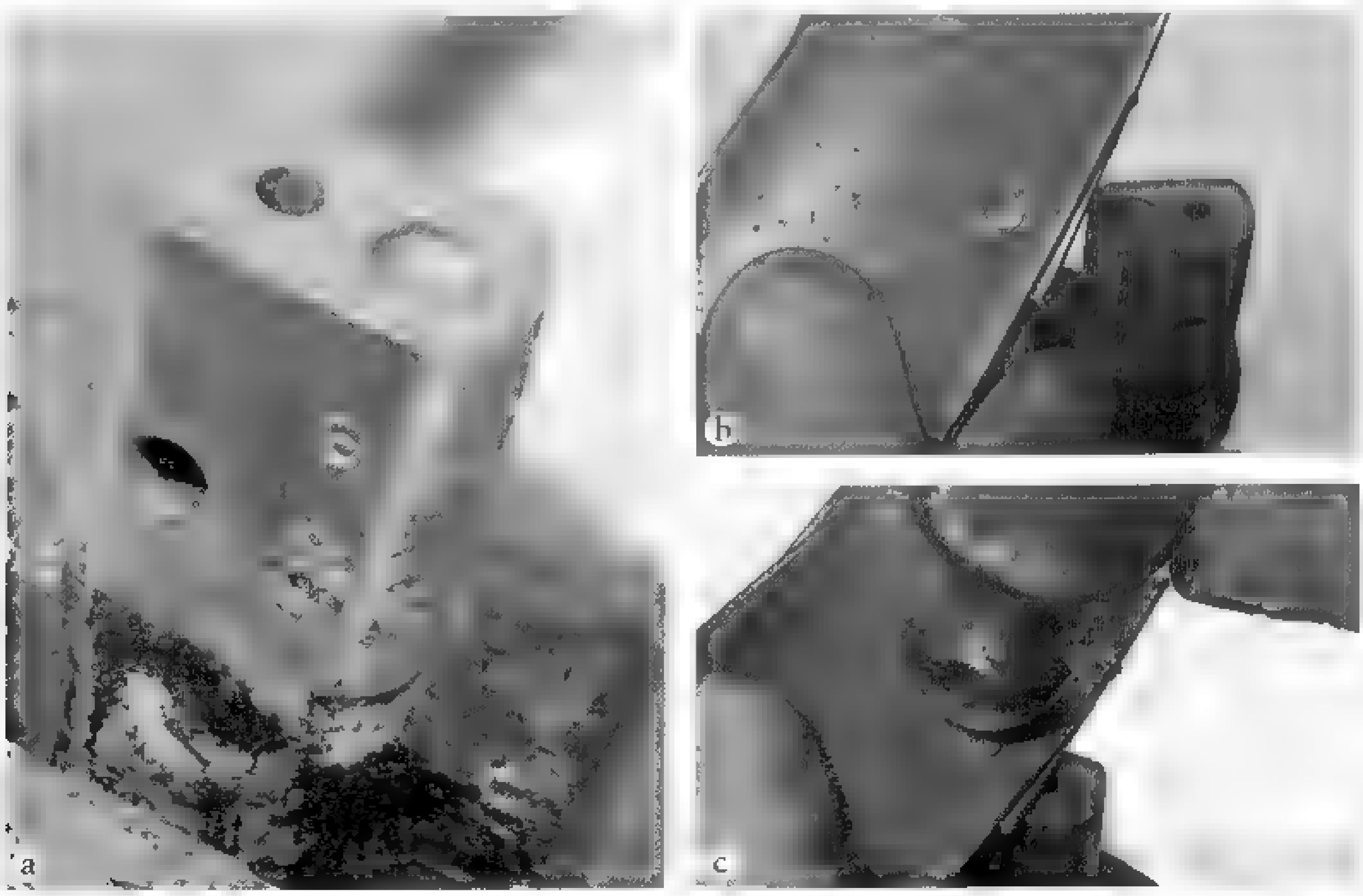


Figure 17.8. Piening a rivet using a set

During the 15th century and into the 16th, a large semidome-headed nail (something like what is now called a truss-head rivet) was used but often with a larger head than is now available commercially. The head was sometimes decorated with file work, incising lines in floral motifs.

To set a strap on the outside of a plate, a 1/8, 5/32, or 3/16 inch hole is punched into the metal, depending upon the diameter of the rivet selected (fig. 17.6a). Truss-head rivets are available in each of these sizes, although they are relatively difficult to find compared to the more normal domed-headed variety. A similar hole is punched in the leather with either a rotary or hand punch (fig. 17.6b). The rivet is passed through the outside of the strap (fig. 17.6c) and then simply piened over through the back of the metal (fig. 17.6d), firmly holding the strap in position (fig. 17.6e).

The second method uses a 1/8 inch or so diameter dome-headed rivet set into a thin, embossed washer. While examples of this technique exist from the 15th century, it was the standard technique during the whole of the 16th century.

Plate-to-Plate Attachment

Rivets or round-headed arming nails are commonly used to attach plates to plates with varying degrees of rigidity.

Round-headed rivets with a 3/16 inch diameter are very close to the rivets that appear to have been used on the earliest articulations from the middle of the 14th century. One-eighth-inch diameter rivets, or something similar, appear to have been used regularly in the construction of the 14th century great helm.

Plate-to-plate attachments either fix a plate rigidly in place or allow the plates to move in relation to one another. First I'll discuss setting of a rigid rivet.

Select an appropriate rivet according to what is closest to the originals. Three sixteenths of an inch is perhaps the most common average size, although there are certainly instances where smaller and larger rivets were used. Punch a hole in each plate the same diameter as the rivet itself (17.7a). The use of a punch rather than a drill will often eliminate deburring of the hole and is in most cases faster. In some cases, flashing or oxidation on the rivet will require that the hole be enlarged slightly with a drill. A worn punch and die set may also punch a slightly smaller hole than is desired.

In Figure 17.17b, the rivet has been pushed through both pieces. Using end clippers, the rivet is clipped to leave between 1/16 and 1/8 inch of shank (fig. 17.7c). On 3/16 inch and larger rivets, clipping them in this way might prove difficult, in which case they must sometimes be shortened in advance with bolt cutters or by sanding them to size. Using the rounded head on a ball-pien hammer, the rivet is mushroomed to snug the plates together (fig. 17.7d); the hammer's flat face is used next to finish the rivet (fig. 17.7e). When done, the rivet (fig. 17.7f) should appear finished and the plates should be snug.

In order to maintain the rivet head's rounded shape, the head can either be supported in a modern rivet set (fig. 17.8a) or a lead block. Using the set is relatively simple (fig. 17.8b), although care must be taken not to tilt the work or the edge of the set can dig into the plate's face. I prefer to use a lead block (fig. 17.8c) since the plate cannot be marred in the process.

A contemporary inventory from Dover Castle in 1344 presents a tantalizing entry for a tool Charles Ffolkes believed was for closing rivets: "*ij instrumenta ad ferram cinendum.*" In 1361, another inventory from the castle had a similar entry: "*nailetoules per clause en ecels fair.*" While these are interesting clues, there is no indication how they were used or if they were anything like the modern tool.

Articulation Rivets

For riveting an articulation, the process is a bit more difficult. The trick is to secure the plates in place close enough in relation to each other that the articulation itself does not gap and yet allows the necessary movement.

Three solutions are commonly done. Some armourers use a slightly larger hole on the

middle plate (the one sandwiched between the inside plate and the rivet head). Generally they drill or punch this plate one size up (5/32 inch if using 1/8 inch rivets, for example). While this does add additional mobility, I believe it also adds too much movement to the plates.

Another solution is to add a washer to the inside (fig. 17.9a), piening the rivet carefully and being less aggressive with the mushroom so that it does not snug the plates together too much. While this technique is necessary for sliding rivets, and I have seen it on isolated medieval examples, it is unnecessary. For sliding rivets, small washers should be made by hand from squares of material by simply clipping the edges and punching a hole into the center (fig. 17.9b).

The best solution is to proceed as usual with a plate to plate riveting, using the same size hole as the rivet (fig. 17.11). By working the edge of the rivet more than the center, the mushroom can be bloomed without drawing the plates together. One tool that is useful for piening these rivets and insuring the requisite space between the mushroom head and the articulation plate is a small spacing tool that can be made quickly from spring steel (fig. 17.10a). A similar tool can

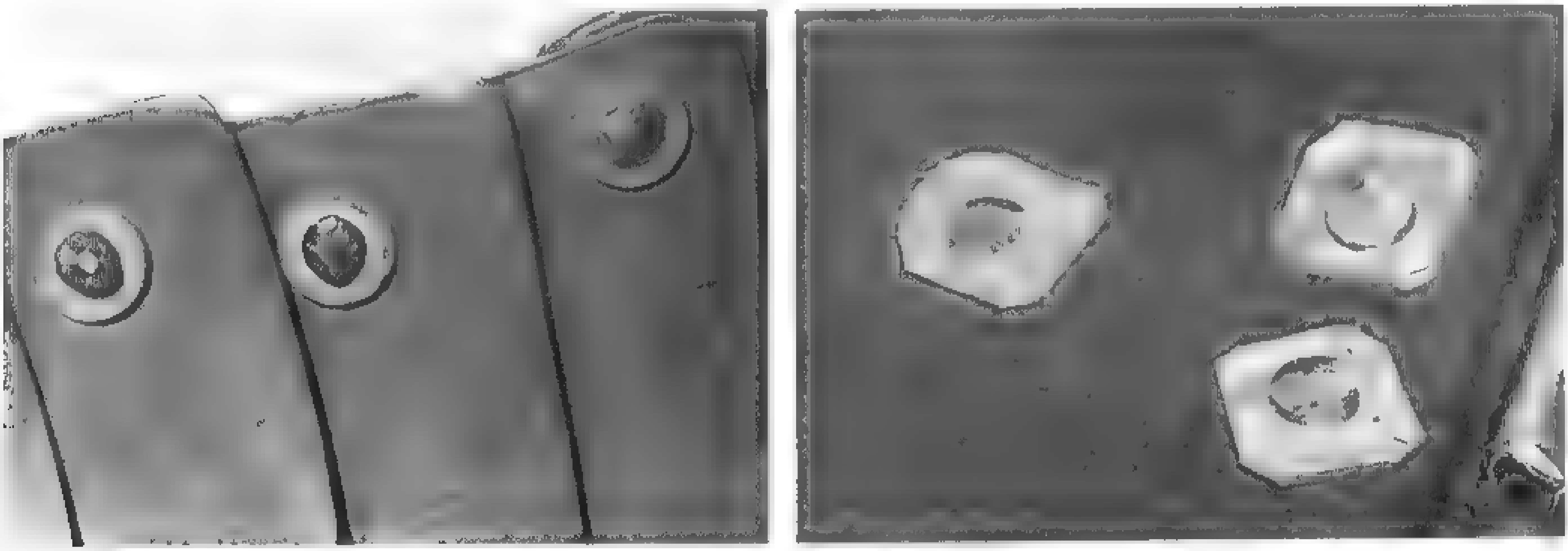
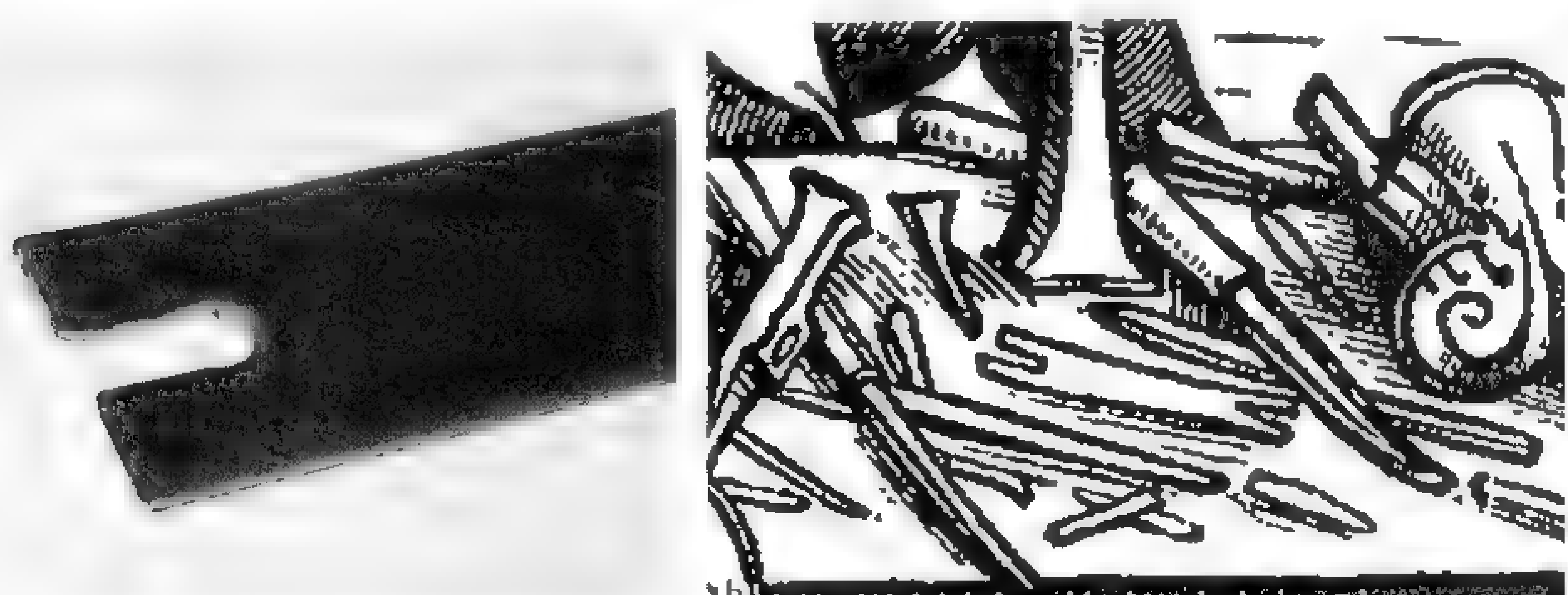


Figure 17.9. These round headed washers are used to cover sliding rivets, although a more correct (and certainly cheaper) style of washer is shown (right). These are easily made by cutting strips of steel, nipping the corners, and punching the appropriately sized hole in the center.



a

b

Figure 17.10. A rivet spacer can easily be made from a piece of scrap spring steel banding. Such black banding is commonly used to secure heavy loads and is generally thrown away. At right, a rivet spacer is seen in Maximilian's workshop (fig. 6.1). Many thanks to Aaron Toman for drawing my attention to this intriguing section of the famous woodcut.

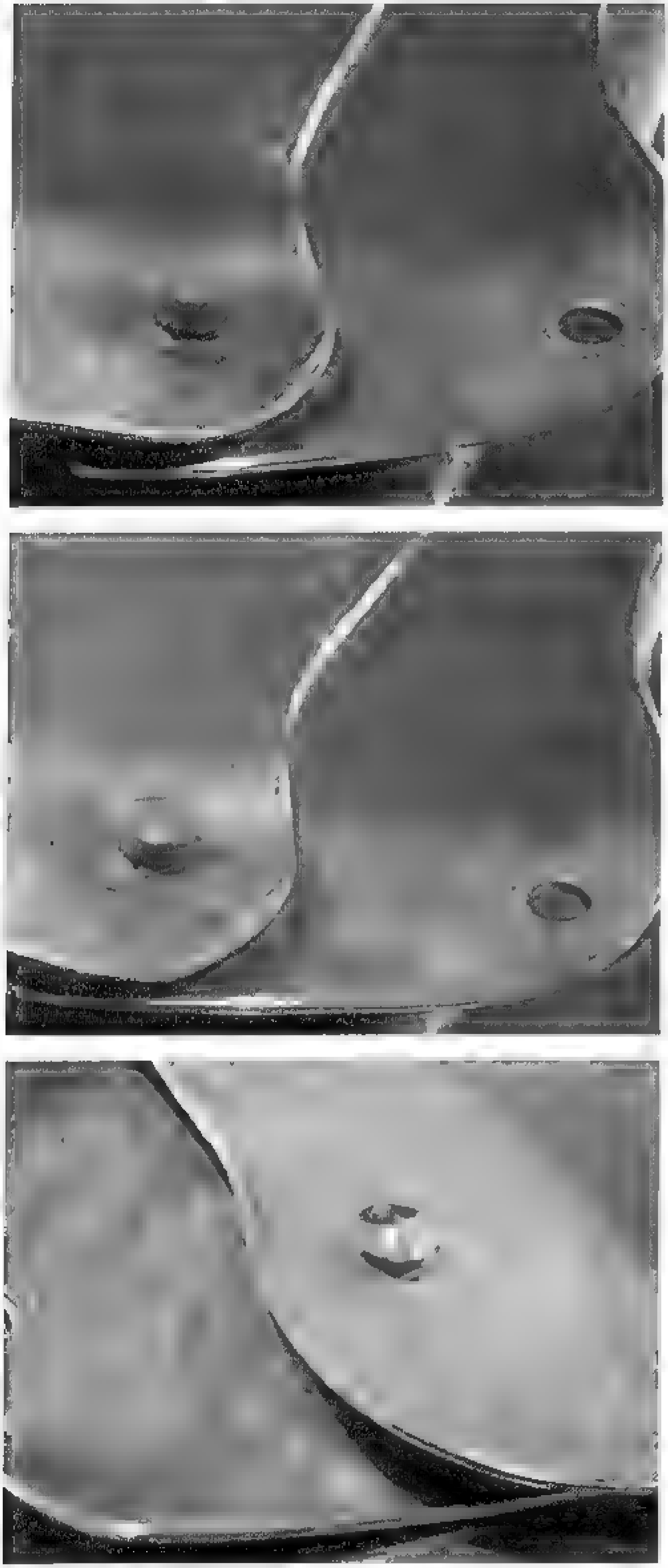


Figure 17.11. When piening rivets for an articulation, I have found that it is not necessary either to enlarge the hole (a common solution) nor to use washers on the inside of the rivet. A bit of extra care must be taken during the mushrooming process, but if done well the rivet can be piened without drawing the plates together overmuch.

be seen on the workbench of Maximilian's workshop (fig. 17.10b).

WELDING

For the modern armourer, welding is an indispensable technique, enabling him to attempt pieces that would otherwise be out of his range or speed production of pieces for sale. A bascinet, for example, may be constructed from three pieces, something that is possible for an intermediate armourer, whereas the raised original is probably too difficult. When properly executed and finished, a weld should be invisible on the final product.

A weld is accomplished by heating steel to a temperature at which the pieces can fuse, either under the pressure of the hammer (as in a forge-weld) or by liquefying it and allowing it to flow together, as in a modern oxyacetylene or MIG weld. If done properly, the resulting weld is as strong or stronger than the metals on either side.

Modern welding is a trade in its own right, so only the basics will be covered here. While medieval forge-welded pieces would have been overlapped and smashed to a uniform thickness, welds used in reconstruction pieces are by definition butt-welded, meaning that the plates butt against one another rather than being overlapped. The fit of the two pieces is a concern, although with gas welding in particular a gap can be filled if the welder is skilled.

The metal should be clean and free from grease and dirt, either of which can add unwanted impurities to the molten metal and cause poor metal flow. The plates should be secured to one another, ideally with clamps (fig. 17.12b), and the work should not be able to shift, as the metal can shift under the application of heat during the weld.

There are a variety of different tips used on the torch itself for welding material of different thicknesses (fig. 17.12a). I use the #0 and #1 sizes most frequently, reserving the #2 tip for welding barstock (as in grilles).

For thin materials (20–14 gauge), select a #0 tip, ensuring that it is clean by using a tip

cleaner to remove carbon scoring from the face and nozzle. Carbon in the passage can result in a buildup of gas that creates an audible "pop" when the wad of carbon is finally expelled, potentially splashing molten metal around the workspace.

Welding gloves and glasses should *always* be worn when welding. Set the amount of acetylene and oxygen pressures according to the recommendations for your specific rig, generally 5 psi of acetylene and 12–16 psi of oxygen. Specific tables with recommendations for tip sizes and gas pressure can be found in most welding books.

The acetylene is started first, using a striker to create a spark in front of the flammable gas. To create a flame that is hot enough to liquefy steel, oxygen is then added to the mix to get what welders call a "neutral" flame (where the fuzzy "middle" flame disappears, leaving a

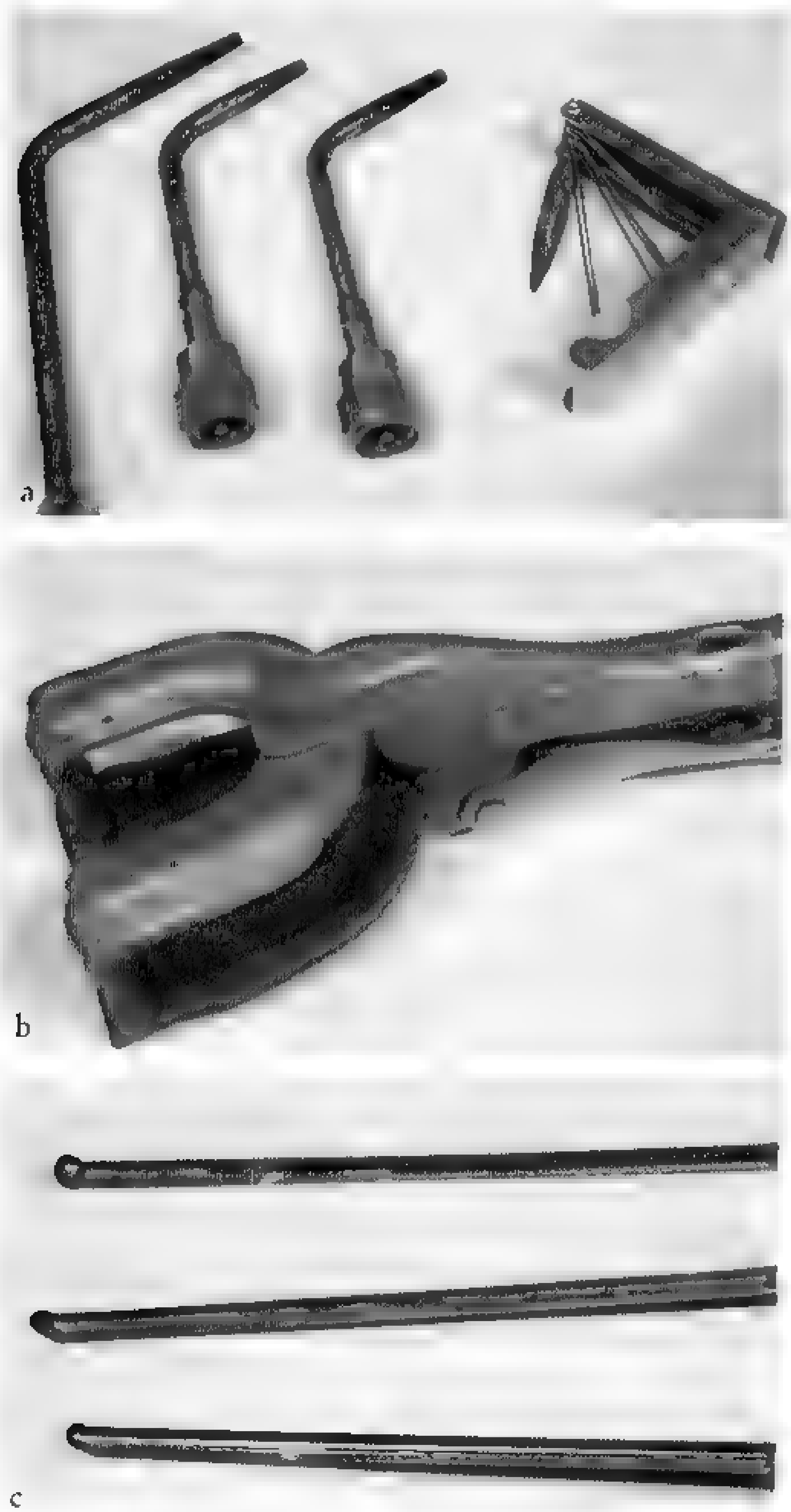


Figure 17.12. Tips for gas-welding torch and a tip cleaner (a), special vice grip for welding (b), and copper-clad welding rods (c)

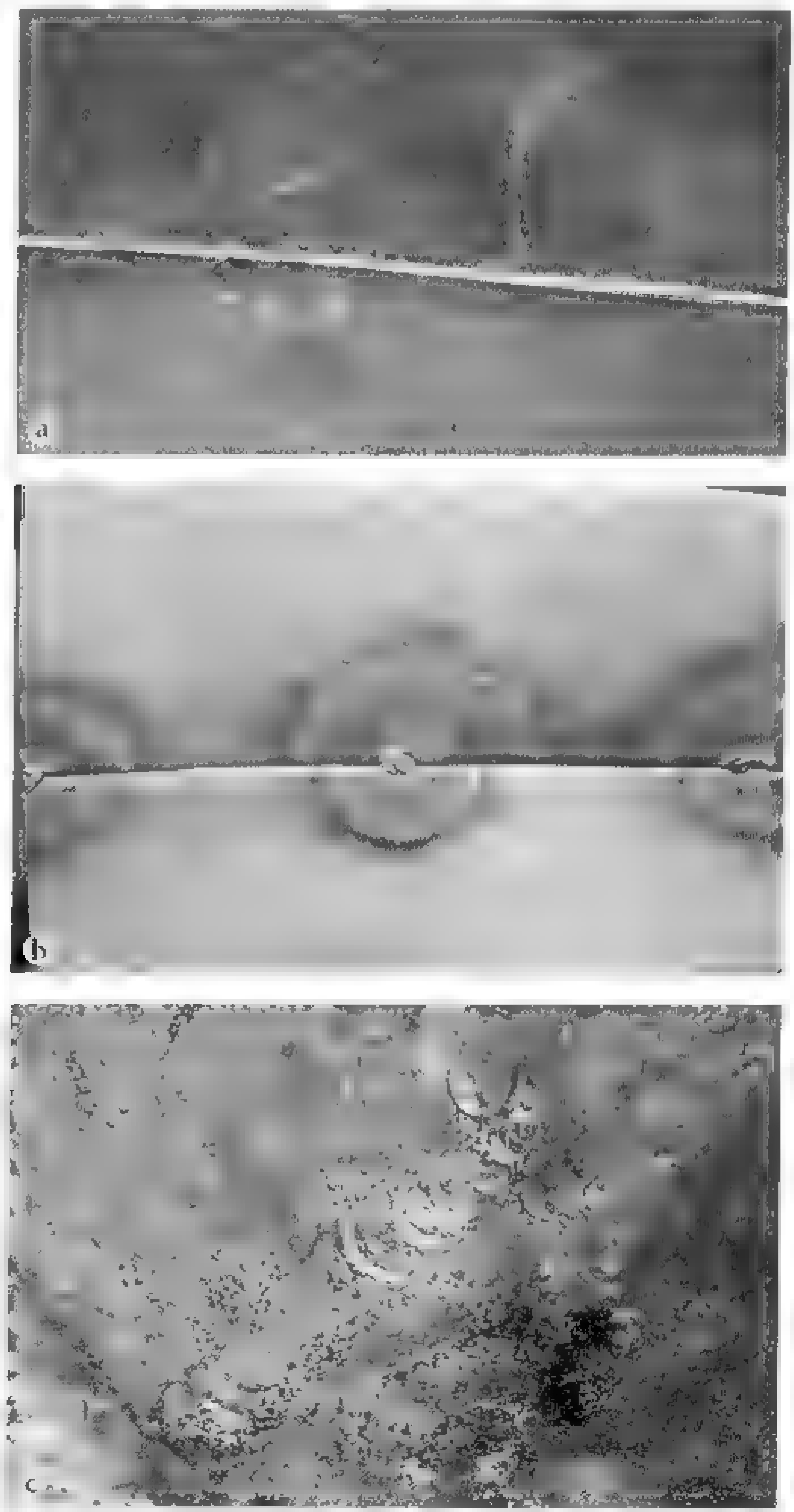


Figure 17.13. Welding sheet steel

It would appear from medieval record entries that the armourer purchased rivets from a specialty vendor, perhaps a wire drawer (a tradesman who used drawplates to fabricate wire), rather than making them from scratch. Notice that the term "rivet" doesn't come into use before the early 16th century.[3]

Reference from the privy seal of Henry VI, c. 1485:
"It'm vj armyng nales."

Ordinances of Chivalry, fol. 123b (*Archeologia*, LVII), c. 1460:
"Also smales nayles a dosen."

Acts of Sir John Howard, c. 1465:
"20,000 Bregander nayle 11s, 8d."

Equipage of Henry, Earl of Northumberland, c. 1513:
"Leather, botkills & naylles for mendying my Lordes harnes."

Record Office, 9 July, to John Blewbery, c. 1514:
"500 gauntlet nailes."

Record Office, April, Richard Pellande Rauffe Brand, Richard Cutler, and Hans, c. 1520:
"four of the king's armourers, brought to the Field of the Cloth of Gold all sorts of necessaries for armour, such as buckles, files, chisels, punches, hinges, hides and rivets."

Record for the Royal Armouries at Greenwich, c. 1544:
"Item in nailes and buckles for both shops monthly."

State Papers of Elizabeth, c. 1562:
"Due also to the armorers of the Tower for their wages & for leather, buckels, nailes & other paiments in indent to the said armory at the feast of Christmas last past ...vj and xv."

Sir Henry Lee's account for the Tower armoury, c. 1622:
"Redskins for bordering of armour, calfskins for the same, leather for gauntlets, round-headed nails, tynned nails, flat headed nails, white nails, yellow nails, double buckels, nails and taches for gantlets, copper nails, brokases, tracejoyntz."

small, hot inner flame and a larger outer one). Too little oxygen will leave the hot inner flame fuzzy and will result in a poor heat, plus excess carbon will build up on the tip itself. Adding too much will trap extra oxygen in the weld, creating porosity that results in a poor bond.

Once you have a neutral flame, take up a 3/32 inch welding rod. The rod itself is generally copper-clad steel, the copper keeping oxidation from the steel's surface and helping it to flow (fig. 17.12c). The torch is generally held in the right hand, the rod in the left.

Preheat the area to be welded by slowly working the torch from side to side, not quite to the point where the surface begins to discolor. This preheat will help the bead flow more efficiently. I like to tack the plates in several places before starting the bead to insure that nothing moves as the bead is run (fig. 17.13b). This can be quite a problem, as plates

will twist under the application of such aggressive heat. It is usually helpful to tack the joint in several places to keep it from moving out of position under the heat.

Generally speaking, I like to start from one edge and work to the other. The bead should be made in a single pass, the torch worked in small circles. The idea is to heat the metal up to a straw yellow, after which it will quickly melt. If the rod is not present to add just a touch of extra metal, then a hole will likely form. Rod is fed into the bead as the welding progresses from one side to the other, but it should not be added until the puddle is depressed and just short of becoming a hole. This insures that the weld is made in a single pass, without recourse to laying another bead from the backside. It does take a great deal of touch and practice, however, so the novice armourer should do a bit of work on practice sheets before progressing to a combat piece. Welding courses can be taken at most community colleges and are highly recommended.

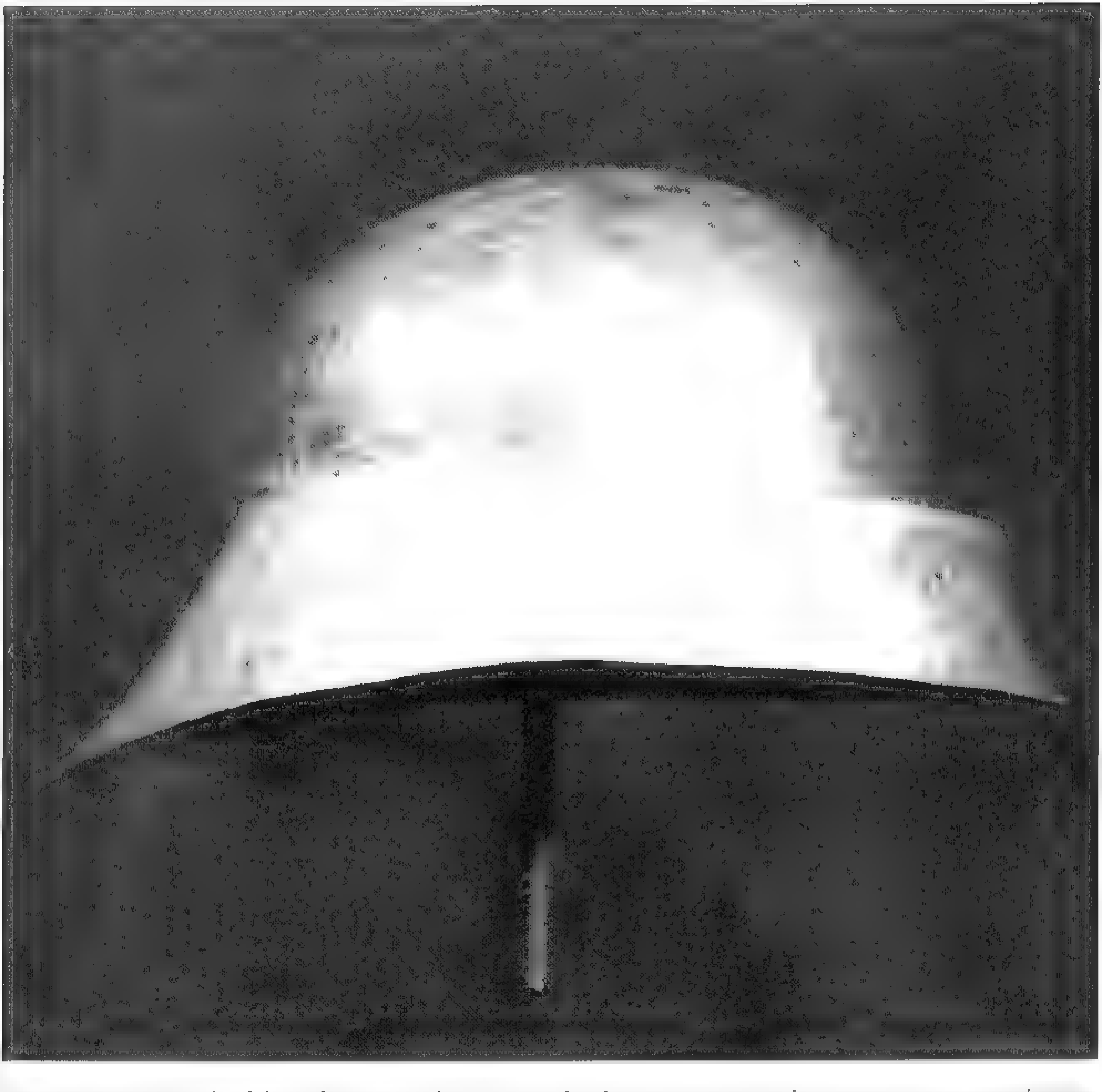
The finished bead should show signs of good torch movement (because the metal is well-mixed, yielding a strong join) and should have just a hint of material to be sanded away. When sanded, the resulting weld should be invisible from the outside.

ENDNOTES

1 Alongside this helmet is another that very closely resembles it and for a time was considered to be a fake made by the infamous Samuel Pratt, antique dealer, armourer, and 'faker' of the 19 century. Today it is considered to be authentic; both are examined in more detail in Chapter 30.

2 Dr. Alan Williams, private conversation with the author, August 1999.

3 Ffoulkes, Charles. *The Armourer and His Craft*



[illegible] Raising — the ability to hammer metal over forms rather than into cavities — is the most important [illegible] [illegible] shaping of planes. Raising [illegible] [illegible] most novice and intermediate [illegible]

Chapter

Raising: The Cornerstone Technique

Raising is the keystone technique for mastery of the armourer's art. Rather than working from the inside, as in doming operations, the piece is worked from the outside, yielding superior control of the works' shape, thickness, and degree of flare or dome. Raising is the most challenging technique set to learn, so an exhaustive treatment of raising is beyond the scope of this introductory volume.

Most pieces covered in this book were domed or stretched from the inside. This is a speedy process, but it thins the metal and gives the armourer little control over its thickness. While the intermediate and advanced armourer will probably always use doming to some degree, to create the best work the armourer must master techniques of working the metal over stakes, compressing or shrinking it into shape and carefully controlling the metal's behavior. This is done through raising, the cornerstone technique for advanced armourers.

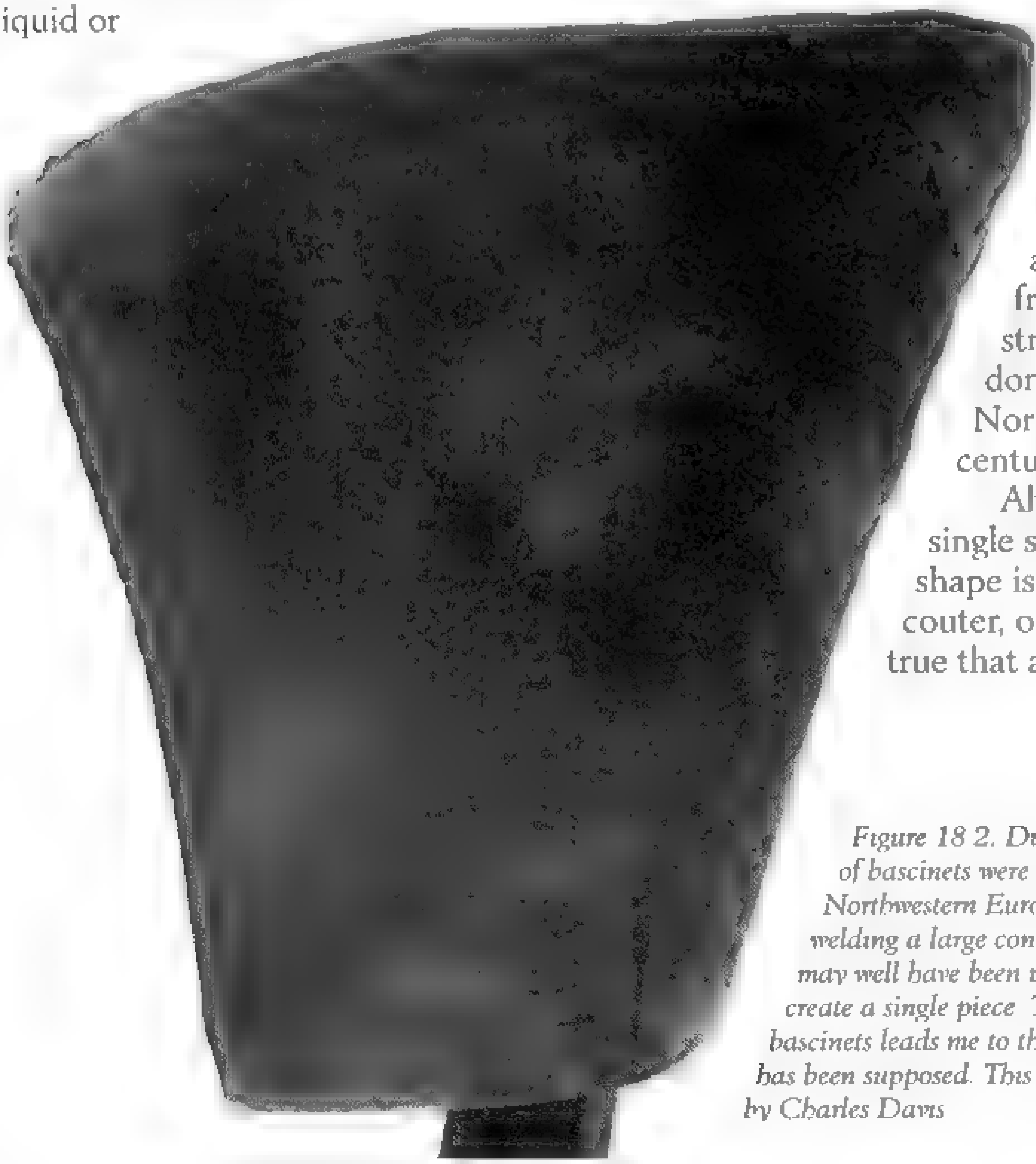
The armourer who takes his craft seriously should endeavor to first master curling, doming, bouging, and planishing before focusing on raising. But long before this, he will find numerous cases where a simple arc proves insufficient for the complex shape required of a piece, particularly in the production of gauntlets, couters, poleyns, and visors, all of which feature deeply

domed surfaces that are superior when formed through compressing rather than stretching technique.

Raising is essentially forming the metal by compressing it around a form. The work is held against the form and then pressed down to it, in the process jamming the steel's molecules together tightly and forcing them to move as an extraordinarily viscous liquid. If the armourer can control this process, he can obtain great freedom to move the metal as necessary in service of the lines so exhaustively studied in the examples of authentic harness. This control of the metal is requisite for mastery of the armourer's art alongside similar skills in joinery, finish, enhancement, and artistic judgment.

In all raising operations the metal is pinned against a metal stake and struck, forcing it down to the stake's surface and thereby compressing it to shape. If the metal is thought of as an exceptionally viscous liquid or malleable plastic, this can help in creating a mental picture necessary to "push" the metal around as necessary. Generally, oval or rectangular hammers are used over ball or mushroom stakes. In order to achieve control in the raising process, several factors must be monitored carefully: the angle at which the work is held, the point at which it is struck, the angle at which the hammer strikes, and the uniformity of blow force and placement.

Raising requires superior hammer control. While very small plates such as lames can be domed, helmets, breastplates, gauntlets, poleyns, and couters can and should be created by raising as the armourer reaches a higher level of skill. Early on he should learn the lines of a piece using the less-advanced techniques, but it is certainly worth striving to learn proper raising since it offers superior control over a work's symmetry, metallurgical properties, and authenticity.



HISTORICAL EVIDENCE

Although the creation of a helmet bowl from a single sheet of steel takes several times as long as creating a similar one from welded pieces, there is strong evidence that raising was done in Europe on one-piece Norman casques as early as the 11 century, possibly even the 10th.

Although raising or pressing a single sheet of iron down to the desired shape is the best way to form a helmet, couter, or poleyn, it is not necessarily true that all pieces were so made.

Figure 18.2. During the Hundred Years War thousands of bascinets were needed by combatants throughout Northwestern Europe, and shortcut techniques such as welding a large cone from which to start the raising process may well have been used to economize and shorten the time to create a single piece. The flat-back high-point nature of bascinets leads me to think that this might be more common than has been supposed. This helmet has been raised from a welded cone by Charles Davis.

Medieval requirements for large numbers of helmets, and the expense of large sheet iron or steel, may have encouraged the use of forge-welding techniques, both to create sheets large enough for raising to begin and to cut the time required to hammer a deeply drawn piece such as a bascinet or pointed visor. The weld itself would be invisible on both the outside and interior, visible only to X-ray analysis. Since armourers were not in the habit of recording their techniques, we have to wait on modern X-ray studies to answer the question definitively.

The evidence suggests that some measure of forge-welding was were used to create cones from which pigface visors were raised, and forge-welds were certainly used in the construction of some extant great helmets from the 14th century. Additionally, I have examined one of the Churburg bascinets—Royal Armouries IV.470, the "Lyle" bascinet—and the visor shows a possible sign of forge-welding. On the lower edge of the nose there is what appears to be a deep pit or crack that might indicate a forge-weld, exactly where modern armourers place their welds. While this evidence is by no means conclusive, it is a distinct possibility.

Metallurgical evidence taken from microphotography does not at first seem to support this supposition. Of the many pieces examined by Dr. Alan Williams, he has seen little if anything to support the forge-welding

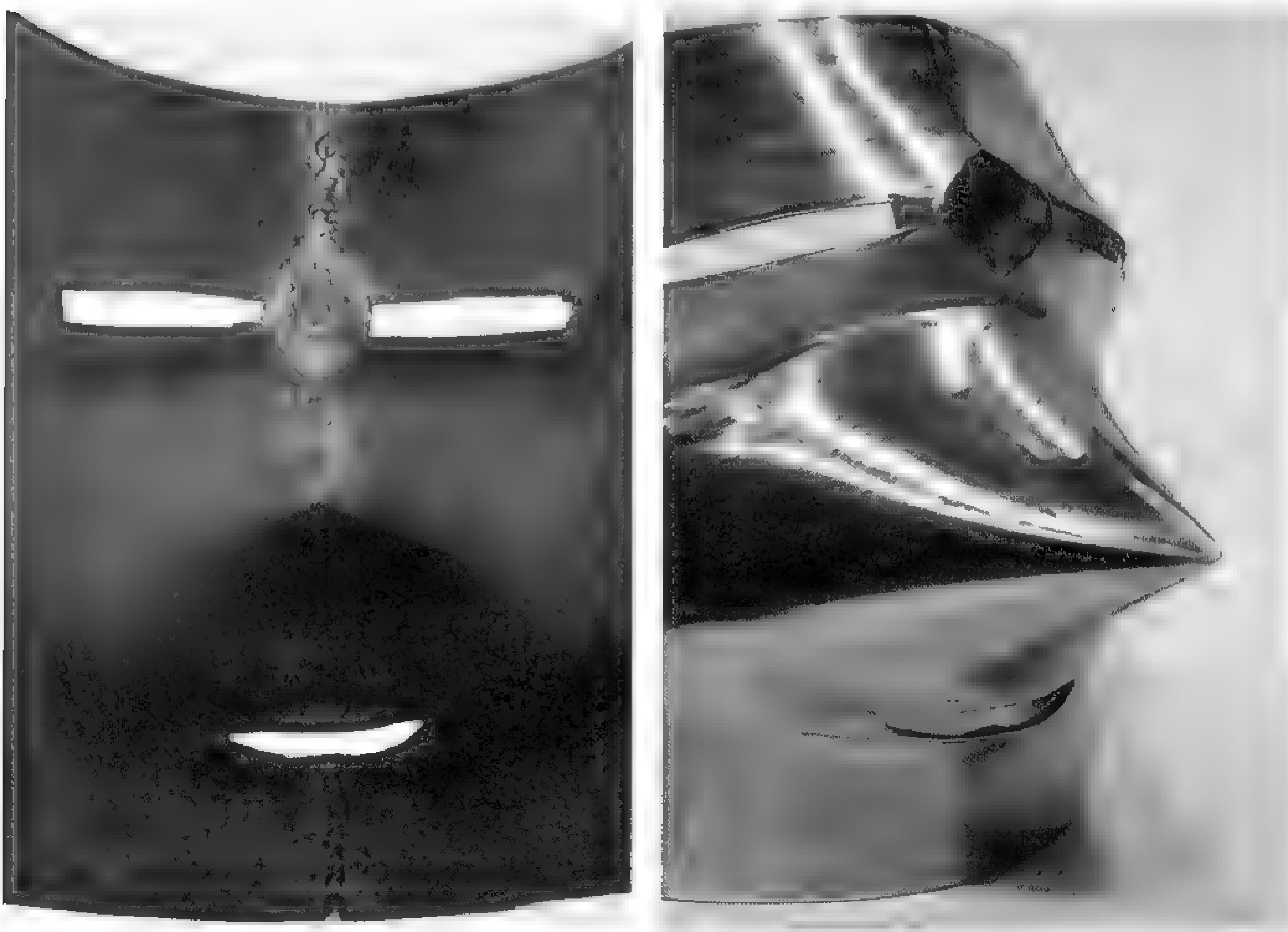


Figure 18.3. It is possible that "hundskul" visors may have been forge welded before raising began to define the eyes and compress the metal around the snout, but without X-ray examination of the remaining pieces the answer will likely remain in doubt. Modern visors are sometimes formed either in halves or with a weld along the under side of the snout, greatly speeding the time needed for such a difficult piece. The above visor is an uncompleted project by the author.

theory. However, because metallurgical analysis is generally conducted on a piece's edge, it is certainly possible that the evidence for such a weld could be overlooked. Additionally, it is possible that the equalizing action of heat-treating may eliminate some of the evidence.

Whatever the outcome of future research, medieval armourers certainly had mastery of raising techniques.

RAISING THEORY

Skillful raising is a combination of hammer control, a precise feel for how the metal is rested against the stake and how it flows under the hammer, and a refined mental image concerning how all the surfaces should appear in the final piece. The baseline technique is not very difficult, but like fine strategy there are a myriad of permutations that cannot be learned from a book and which must be felt through firsthand experience.

Rectangular hammers are selected for raising operations because they push the metal in only two directions. Traditional metalworking hammers use aggressively rounded and pointed faces to move copper and silver, but I have found my best raising results have come from using a much flatter-faced hammer.

Most raising takes place over a ball or mushroom stake, though the shape of the stake will determine what sort of techniques have to be used to extract the desired shape from

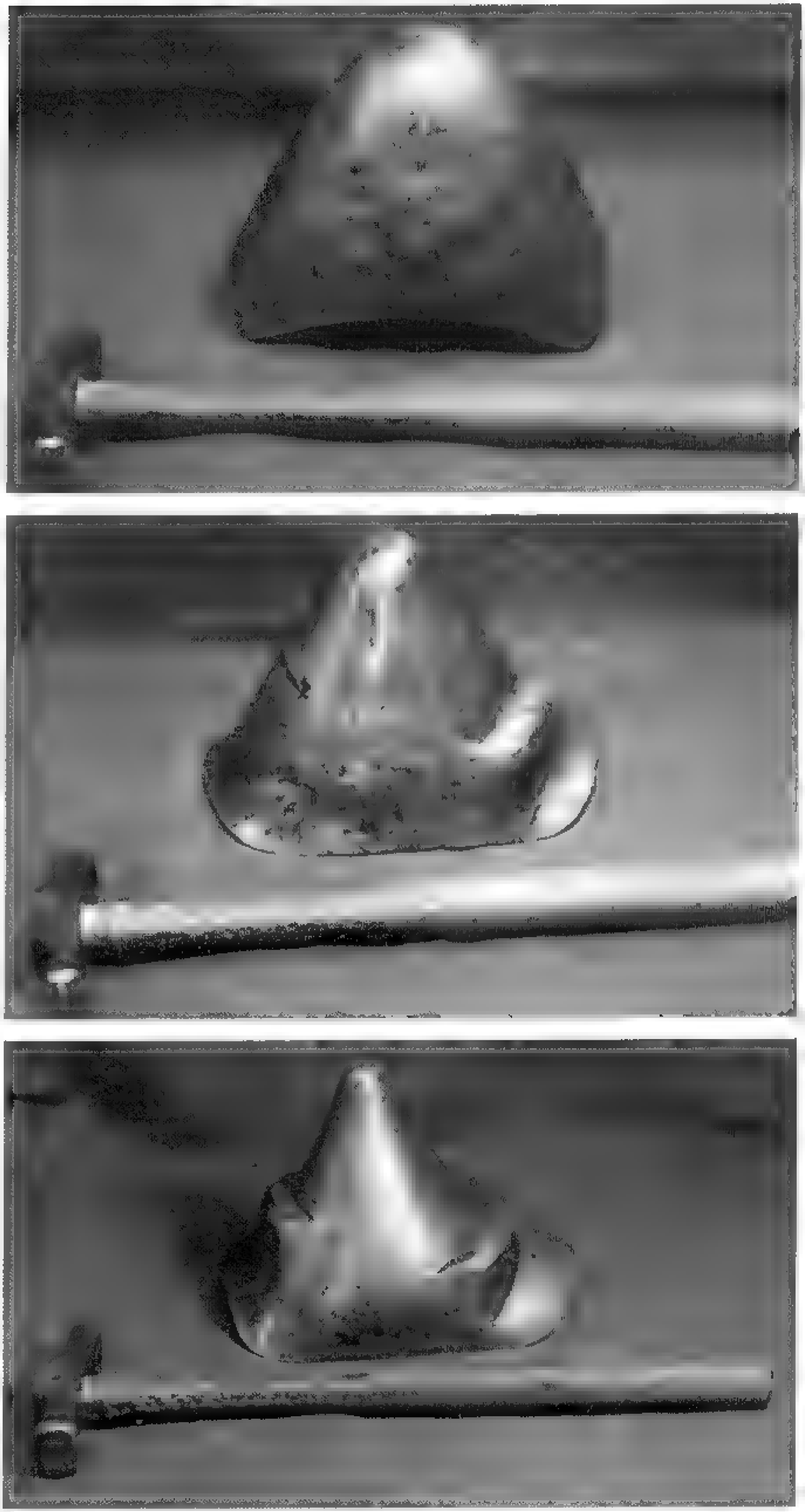


Figure 18 4. Raising a pignose.

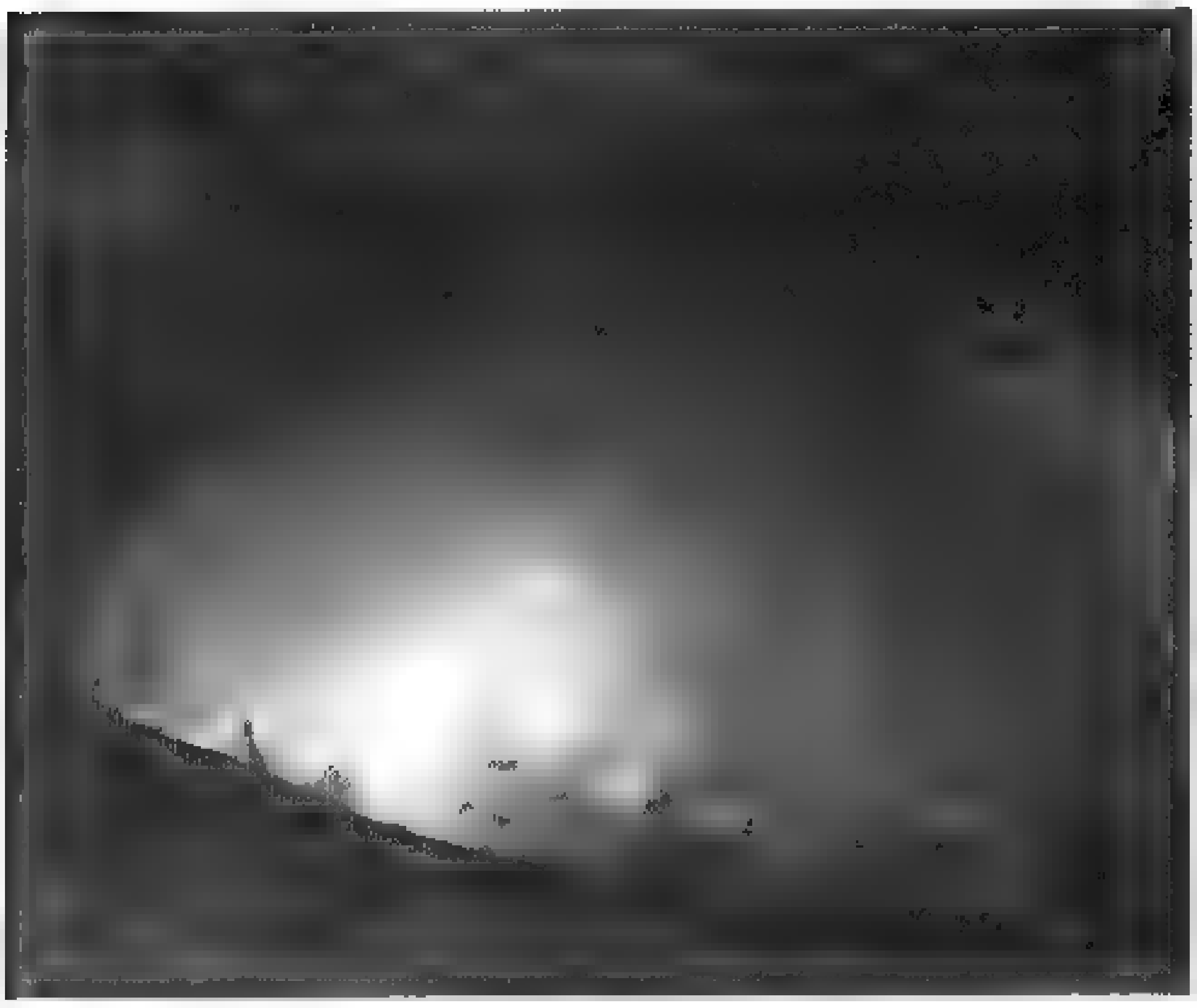
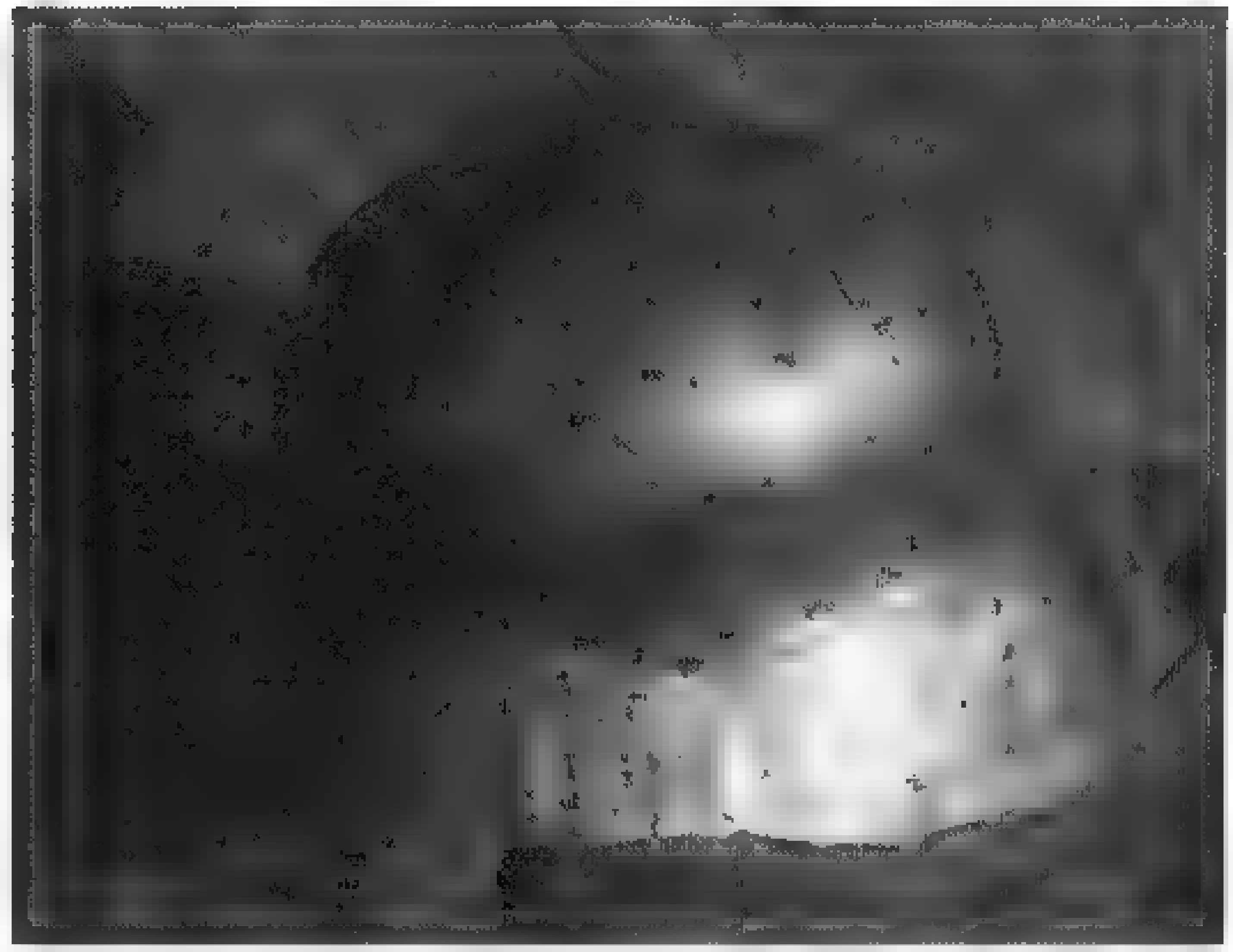
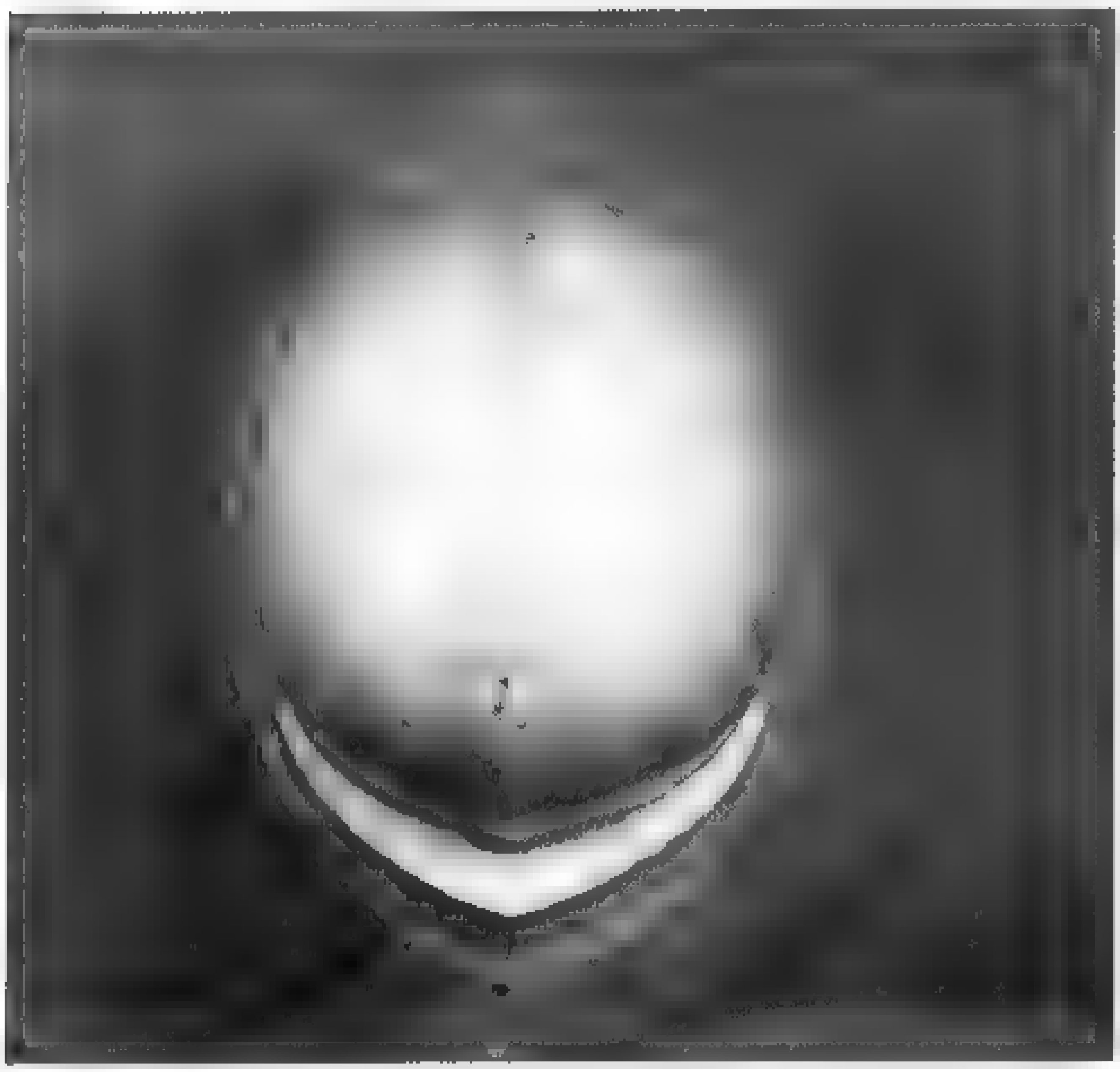
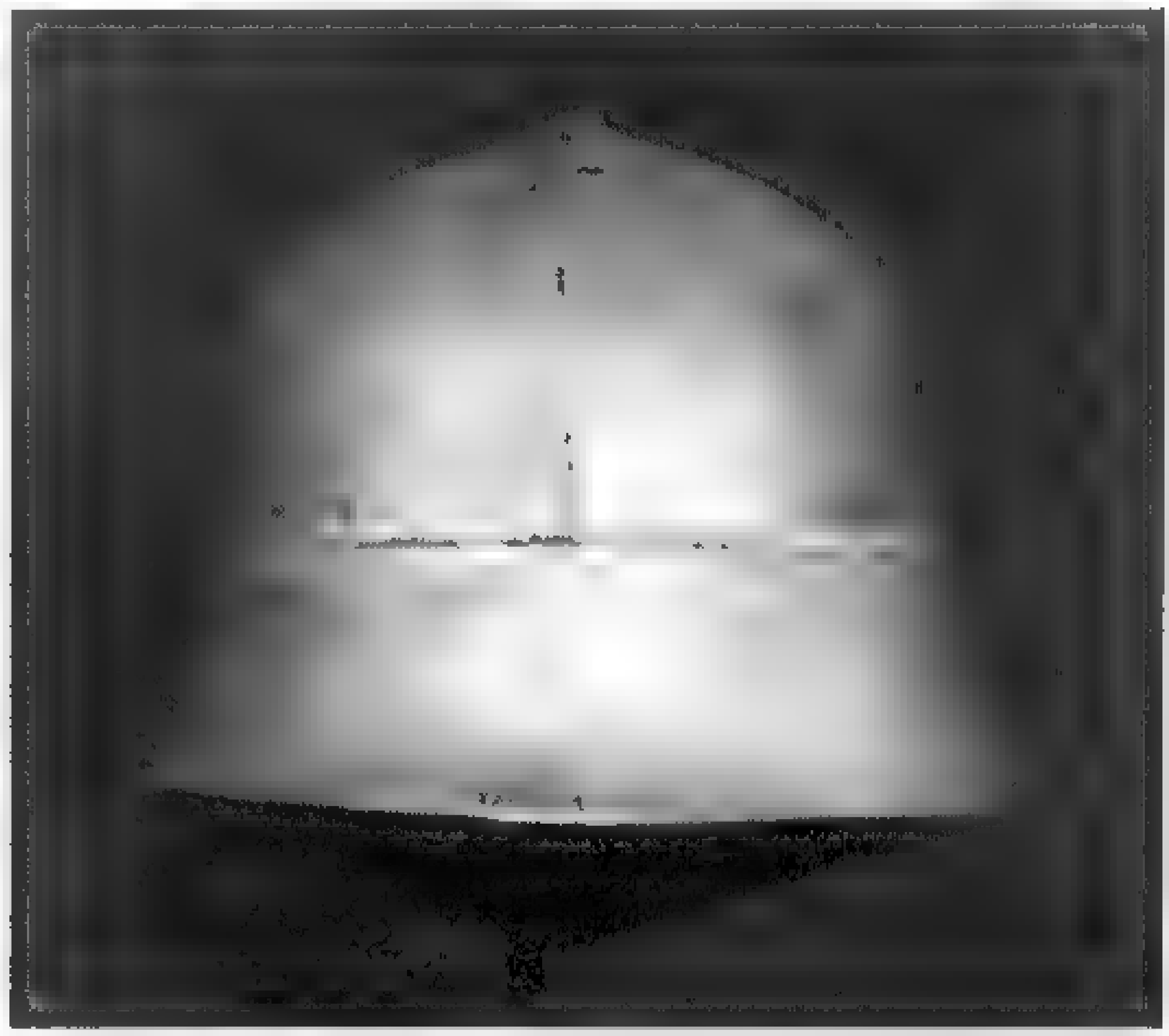
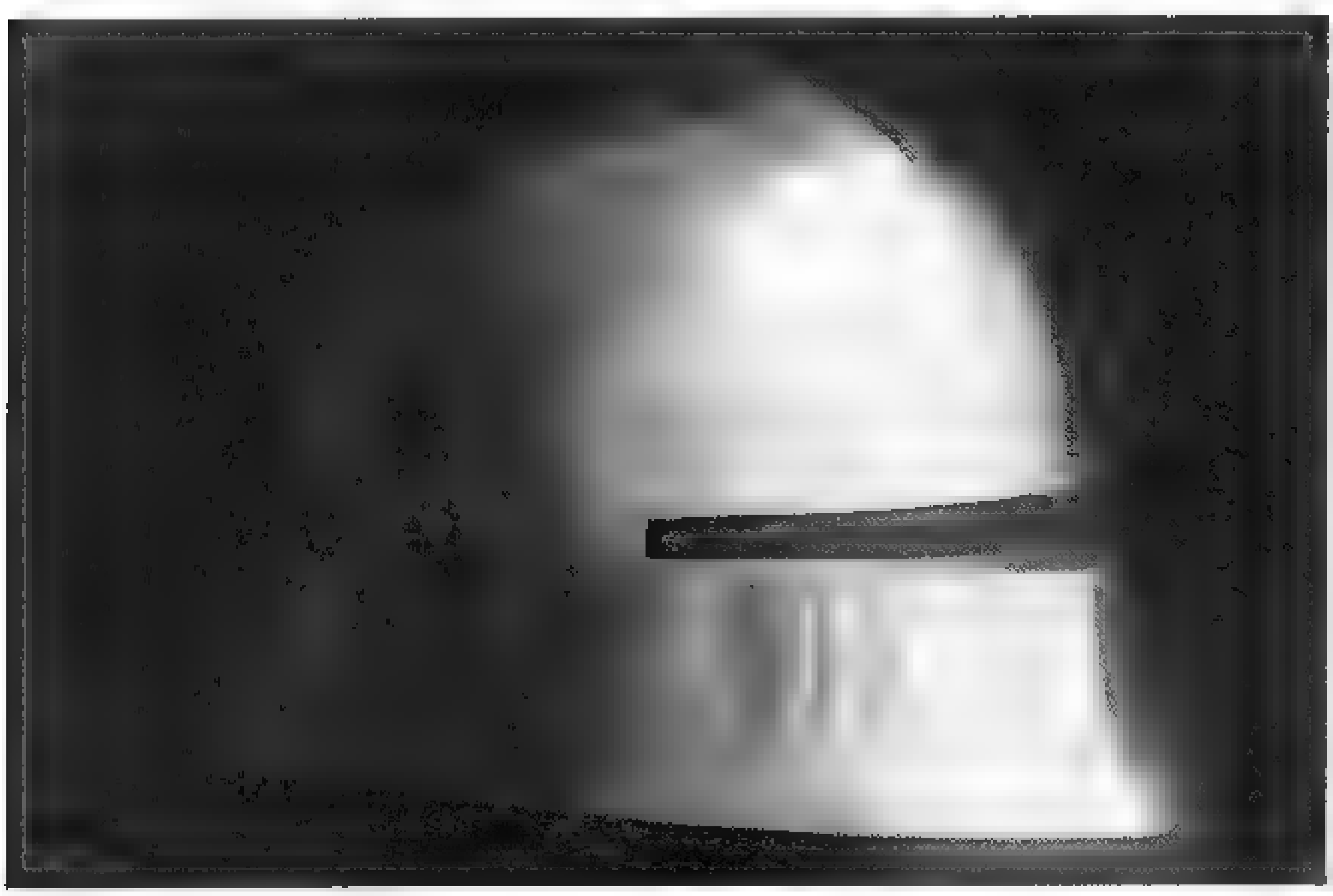






Figure 18.5. In the 15th century the sallet became the dominate helmet on the field possibly due in part to the ease of its manufacture. During the raising process, the metal remaining in a pass tends to remain flared. It is an astute feature of design that was modified slightly and incorporated into a very successful helmet—the same might also be true for the chapel-de-fer of one piece also popular during the 15th century

the metal. I tend to prefer a mushroom shape for most of my raising projects—especially helmets—but T-stakes and stakes of various other shapes can be immensely helpful.

Slight doming can be done to start the process so long as it is carefully done to avoid stretching the metal overmuch. Alternatively, the raising can be done directly from a flat sheet. This is more practical on smaller pieces such as couters, poleyns, gauntlet metacarpal ridges, and some visors; larger sheets are much easier to handle after a preliminary doming pass.

Raising is started from the center of the piece, progressing in a spiral and moving outward in evenly laid courses. The hammer blows actually strike the metal off-center from the stake, driving it down against it. If this is done evenly, the result is a compression of the metal that can be carefully controlled by varying the angle of the piece.

The angle of the metal in relation to the raising surface is critical, as variations in this angle will produce uneven work that is exceptionally difficult to control. Maintenance of a consistent angle throughout the process is the key to solid, even courses.

Likewise, the angle that the hammer face strikes the metal is important. If the hammer strikes at more than 90 degrees, the metal will be stretched and thinned. If strikes are at precisely 90 degrees, then little movement will take place. If the hammer is at less than 90 degrees, however, the metal will be pressed upward and thickened in the process. This is a matter of fine control that is important; keep in mind that the metal acts under this kind of duress like an exceptionally viscous liquid or plastic, and the armourer can move it around as necessary to strengthen the most vulnerable points in a plate's surface.

In the raising process, the armourer must carefully watch the emerging surface to determine when the piece is deep enough, modifying the shape through successive passes until the proper level of depth has been reached. Care must be taken not to cause folds at the edge, since these can quickly produce cracks.

After every pass the piece must be annealed, which can be done effectively with a torch. This step is unnecessary if it has been worked hot.

PRACTICAL CONSIDERATIONS

Helmets should be started in 10 or 12 gauge, couters and knees in 14 gauge. Most raising can be done over a simple ball stake, though it should be offset if at all possible so that the piece can be rolled underneath.

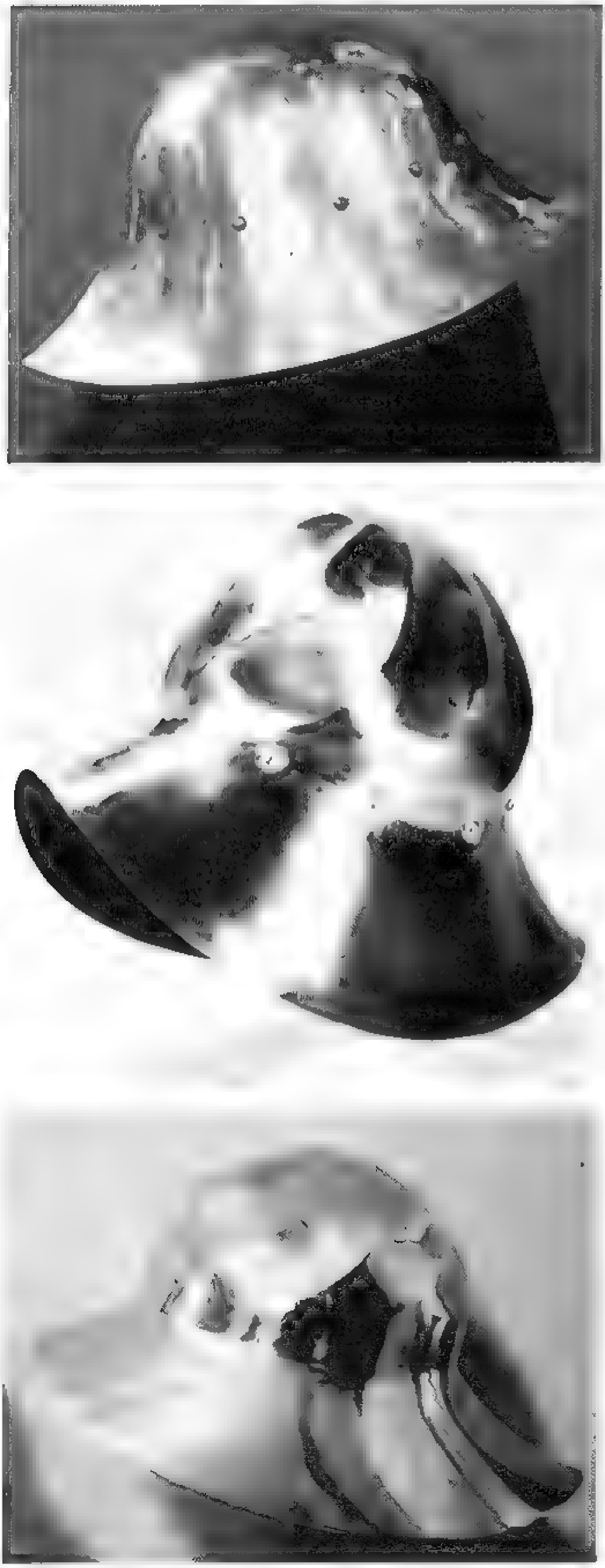
Since heat will be required, at least to anneal the piece, a torch with a rosebud tip or a forge is necessary. If a torch is used, a device called a "gas-saver" can be employed to maintain the desired setting on the torch and to save on the gas required for a single helmet. Using this technique, an intermediate armourer can raise either hot or cold and do a quick, imperfect, but reasonably effective annealing to soften the metal between passes, though a coke forge is the right solution, as the project heats faster.

STARTING OFF

The armourer should probably begin learning to raise with copper sheets, forming sample couters or poleyns, cups, or similar pieces to get the feel for hammering in smooth passes, keeping the piece symmetrical, and moving the metal around. In silversmithing this expertise in hollowware is invaluable, so if local courses are available I highly recommend them.

I then prefer my students to begin creating their poleyns, couters, gauntlets, and sculpted cuisses through raising rather than doming techniques. Greaves and helmets can and should be saved for last, since they are both exceedingly difficult. A great helm top is an excellent first raising project, followed by poleyns and couters. A roundnose visor provides an interesting and challenging prelude to the more difficult pieces to come.

Before attempting a helmet, it is useful to create a model or full-scale version in copper or bronze, since these metals move more easily than steel and thus return results far more quickly. Once the techniques of working with a huge disc of metal necessary for a helmet are



mastered, the real thing can be attempted in steel. Although constructed in several pieces, the armet à rondel or cervellaire present good first projects. Sallets are actually easier to raise than are bascinets, because the flare on the tail and sides of the helmet results naturally from the sweep left in a course of raising once the bowl itself is complete. Bascinets and their deeply coned visors are among the most challenging helmets to raise.

SPECIFIC WORKING TECHNIQUES

Iron and steel can be raised either hot or cold, and there are advantages to both. If worked hot, the metal moves much more easily and does not harden. Unfortunately a large sheet is difficult to wield when hot, and the heating itself takes a great deal of energy if not done in a forge. If worked cold, the metal hardens quickly but is easy to control, as tongs are not required as in hot working. In between passes, however, annealing is required.

There is historical evidence for hot and cold work. Iconographic evidence shows armourers raising or planishing pieces with tongs and with their bare hands, which seems to indicate that medieval armourers did both.

Metallurgical analysis of pieces from the 14th century seems to indicate that the vast majority were worked hot, but I am not completely convinced this is the case since it is possible that if an effort was made to heat-treat the piece, evidence of cold-working may have disappeared.

Without question I prefer cold-working, primarily because the control seems greater and the piece is far easier to manage without tongs. I know of fine armourers who prefer to work hot, however, and it may have as much to do with experience and available tools as anything else.

Figure 18.6 Many armourers do a single-piece chapel-de-fer as their first big raising project. As with a sallet, the extra metal left mid-course is easily turned into the dashingly flared brim. Included here are examples of chapels by (top to bottom) Charles Davis, Theodore Monnich, and Wade Allen

RAISING PASSES

All raising is done in even passes, progressing from the center to the edges. The metal is marked to insure even passes, either with chalk, lead, or permanent marker. I like to inscribe circles 1 inch apart expanding radically from the center outward, the entire circle itself divided into quarters.

A piece of armour requires from between six and 20 passes, depending upon the depth of the piece. With each pass, the metal is annealed.

Luke Apker pioneered a technique in our workshop whereby he raised helmets by quarter; that is, he did a complete pass over 1/4 of the circle's diameter and then moved on to the next quarter until the pass was complete. This worked well both hot and cold but took exceptional skill. I have since used it with great pleasure on smaller pieces, but the real payoff comes with helmets, where the time required to complete the piece is greatly reduced.

In silversmithing, there is a technique frequently taught known as "crimping" where radial flutes are first hammered into the piece and then smashed flat to move the whole piece deeper. Many experiments by a number of armourers have shown that this is not the way to approach work in steel.

FINAL FORMING

When the raising passes are complete, the piece will have a very rough appearance. The next step is a quick bouging pass to eliminate the larger hammer marks. Medieval helmets that I have examined are exceptionally rough on the inside, indicating that medieval armourers might have proceeded no further. It is supposed that they simply heat-treated the pieces (or normalized them) and then proceeded to grind and polish.

The best of the modern armourers planish pieces following the bouging step, then grind and polish. This final pass with a smooth-faced hammer hardens the piece and provides a very smooth surface that reduces the grinding needed.

Chapter

Annealing, Heat-Treating, and Tempering

Once a piece had been shaped to satisfaction, the medieval armourer would often attempt to harden it through heat-treating and, sometimes, through tempering.

There is a strongly running argument in the arms and armour community concerning how much was known about heat-treating during the Middle Ages. Evidence gained through metallurgical studies have shown that many pieces of armour from the 14th century were indeed quenched in an attempt at heat-treating,[1] even though the material had a carbon content that was far too low to harden without case-carburization. Whether or not case-carburization was attempted on these pieces is unknown.

Because carbon steels that have been hardened alone are usually too brittle for use in combat, two techniques exist to reduce this weakness. The first method is to attempt to reduce the shock of the first quenching by slowly lowering the piece into a less harsh medium, such as oil. The slow descent of the piece into the oil is less tramautic for the metal, and if done well gives a tolerable if not excellent combination of strength and hardness. This technique seems to have been preferred by the Milanese armourers during the 15th century, though it is very difficult to

Opposite page
Figure 19.1. A quenching in progress.

accomplish consistently when the material itself is not homogeneous or is of an even thickness. Indeed "slack" quenching is probably something of an art, different for each piece and highly dependent on the skill of the practitioner.

The second method is a two-step technique possibly pioneered by the Helmschmid family of 15th century Germany. The metal is first heated to the critical range and then quenched, hardening it but also making it quite brittle (indeed it can crack if dropped in this condition!). Next it is once again heated or "drawn" to relax the brittleness and add some toughness, then allowed to air cool. The degree to which the metal is drawn will determine the balance between its hardness and toughness (see table 19.1).

Modern armourers working at the intermediate levels do not usually heat-treat their armour, nor did the restoration armourers of the 19th and early 20th centuries. The reason for this is that most reenactors work in low-carbon steel, which is appropriate for most 14th century armour but which can't be hardened appreciably without resource to case-carburization.

The most advanced modern armourers tend to use the two-step method, working in kilns, because the critical temperatures and times are well known. Some intermediates have made good use of charcoal forges, though care must be exercised as contact with the coal will result in incredibly tough firescale, which will then require reheating with a torch for the drawing. The art of heat-treating depends on so many variables, however, that each armourer will develop variances of heating techniques, quenching materials, and steels used.

A few armourers are using case-carburization techniques to treat their mild-steel reproductions, though this technique is not widely known. Commercial pastes are made to help with this process, but it is time-consuming and, while worthwhile, generally too expensive for anything but the best reproductions.

As the intermediate armourer progresses, he should gain an increasingly technical knowledge of steel and the treatments required to harden it. Even as an intermediate, welding and annealing will be important skills; pieces created using the constructed method require welding, while those created with raising will often need to be annealed.

METALLIC STRUCTURE

Metals are composed of molecules that are bound together in a crystalline structure. When relaxed, these crystals are aligned in an orderly manner, and the metal is more plastic. In this state the armourer can move it around with relative ease.

As metal is worked with a hammer, bent, or manipulated in any other way, these crystals are forced out of their relaxed alignment. The bonds between the molecules are stressed, and

Figure 19.2. It is likely that in cases where extensive raising was required, medieval armourers worked their pieces hot But for detail work or pieces that did not require as much rough shaping, cold work would have been preferred because the work is easier to handle and more precision is thus available (From the Stände und Handworker, c 1590, courtesy of the British Library)

the crystals resist further movement. If forced, the bonds will begin to break and cracks will result. This can easily be seen if a thin strip of metal is bent back and forth; eventually it will break in a ragged line, the bonds between crystals broken.

Likewise, when a metal is hot, particularly when heated to within its "critical range," it remains plastic even during working. The heat allows the metal to relax itself even as the crystals are pushed around with hammer or form. The metallurgical evidence seems to suggest that most medieval armour was worked hot, then either heat-treated or allowed to cool.

Opposed to this evidence are the iconographic illustrations that show armourers working the metal by holding it with their left hand without a glove. If the metal was hot, this would have been impossible. It is possible that the artists were unaware of the actual techniques used within the armourer's workshop, but this seems unlikely since the tools are reproduced with such accuracy.

The majority of modern armourers work the metal cold for most of the production cycle. The finest of them planish their work with dedicated precision, though it is unclear to what degree the medieval armourer finished his armour with the hammer. If the armour is left at this point and ground, with no further heat-treating, then it will be hardened to a degree. This is what is termed "hammer hardening."

Iron that is relatively free from alloying minerals is termed "wrought" iron. Wrought iron is relatively soft and malleable, easy to work but equally easy to deform under the stresses likely to be encountered in combat. In order to transform it to the tougher and hardenable steel, carbon must be introduced in a range from 0.1 to 1 percent. It is the carbon, alongside the techniques used to form and harden an element of harness, that determine the final characteristics. By the end of the 14th century, medieval armourers were experimenting with various forms of hardening and heat-treating to improve the toughness of their product with respect to both deformation and penetration.

An unhardened, soft steel (as in iron or common low-carbon steels) is said to be very ductile; it is easy to bend, can be deformed easily, and retains the new shape when hammered over various stakes. The reason for this is that the metal's crystals, evenly distributed throughout the sheet, are in a relaxed state and easy to move. As the metal is hardened, either through working (work-hardening) or through treatment with heat and quenching, its ductility is reduced.

A metal's hardness can have different qualities depending upon its composition and how it is hardened. Roughly speaking, the performance of steel under the stress of combat varies between two poles. At one end of the spectrum, the *toughness* of a steel measures its resistance to shattering under impact. At the other end, a steel's *hardness* represents its resistance to penetration. A steel that is hard will resist penetration—as in an arrow's bodkin point—while it is more likely to shatter under impact. A steel that is tough is better for components that must endure repeated impacts without shattering. Ideally both characteristics would be maximized, but the nature of the steel does not allow for both. The optimal balance is largely a matter of context, depending upon the type of stress to which the armour is to be put, the relative budget for the project, and the facilities/knowledge available.

For years the characteristics of early armours' metallurgy were a mystery, hidden by the veil of time that separated the medieval armourers from modern students. Thanks to the work of Dr. Alan Williams and others, studies in metallography have laid the foundation for a whole corpus of study of the composition and metallurgical performance of armour, and some light has been brought to bear on the hardening and composition of Medieval and Renaissance armours. Dr. Williams has written prolifically on metallurgical examination of many armours, compiling a database of characteristics on hundreds of authentic pieces. From this writing and from other works built upon his work, we now have an idea of how much the

medieval armourer knew about his materials and how he worked them.

Metallography is the microscopic study of metals that have been polished, etched with a mixture of nitric acid in alcohol, and examined to deduce the metal's composition, heat-treating, and working histories. By careful analysis of a metal's crystalline structure magnified between 100 and 500 times, a good deal can be learned about how it was formed. Because the techniques used in metallography are relatively nondestructive to the armour, many tests have been run on armour components from all periods, resulting in an excellent store of information from which analysis can be drawn.

The resulting analysis concerning hardness and toughness can be validated by direct measurement of the Vicker's Pyramid Hardness (VPH). This is done by impressing a tiny pyramid-shaped diamond into the metal's surface under a known load in joules/mm^2 and measuring the size of the indention. Steel ranges from 150 to 450 VPH (Kg/mm^2) have been obtained from armours dating from the 13th to the 17th centuries.

Another scale frequently used in the discussion of hardness is the Rockwell Hardness Scale. Rockwell hardness testing is another indentation testing method where an indenter is impressed into the test sample at a prescribed load to measure the material's resistance to deformation. A Rockwell hardness number is calculated from the depth of permanent deformation of the sample after application and removal of the test load.

The hardness range possible is determined by the amount of carbon and slag inclusions in the steel, while the exact number within the range depends on working and hardening or treating techniques. Soft iron or low-carbon steels have a range of 1010–1020, medium carbons in the range of 1030–1075, while high carbon steel has a high-end range of 1095 and above.

As is immediately evident, 14th century examples have very low carbon, similar in content to the modern low-carbon steels. Additional study has revealed that at least one helmet from the 13th century and some 14th century pieces were made not from steel but from wrought iron. By the end of the 14th century, armourers were purchasing better grades of steel from vendors whose quality was known, though it is unlikely that they possessed direct methods of empirical testing save for grinding/bending tests. By the 15th century, medium-carbon steels equivalent to the modern 1030–1050 were generally used on at least the better quality pieces.

Unfortunately, as mentioned above, hardness is only one quality that affects an armour's durability. Hardness will describe a metal plate's resistance to cutting but not necessarily to deformation. I have found no equivalent quantitative scale for toughness, though some of this can be known by examining the degree of bainite, pearlite, and martensite.

ANNEALING

In order to avoid the cracking that will result from overworking, the armourer should anneal the metal whenever it hardens to the point where cracking is a danger. The precise point at which this will occur depends on many factors: the metal used, the techniques used to work it, its temperature. Experience is the best guide.

Ferrous metals—iron and steels—are softened by heating them to their critical temperature and then allowing them to cool slowly. Nonferrous metal such as latten (brass or bronze) is annealed in exactly the opposite fashion—it is heated to the critical range and then quenched in water or oil.

If a piece of metal is to be deeply raised or worked extensively, it often must be annealed several times at different stages in the project to insure that it remains workable and doesn't crack. Note that each time the metal is heated, a layer of scale caused by rapid oxidation forms on the surface. This scale forms from approximately 1 percent of the metal's thickness, so each time the piece is heated it loses some of its thickness. Moreover, the scale will sometimes remain in the metallurgical record left behind if polished, etched, and examined under the microscope.

To anneal a piece properly, it should be placed in an oven and heated to the critical range, then slowly brought down to room temperature. The proper range will be indicated by the metal's color; it will be a sharp, even, cherry color. The same cherry color applies to a piece in brass or bronze, but it is quickly quenched in a barrel or water to achieve the same effect.

Few workshops have a heat-treating oven available, so the next best solution is to use the forge to heat the metal to the proper color, then remove it and allow to air-cool. Medieval armourers probably used this technique rather than an annealing oven, since such ovens are not pictured in iconographic representations of the armourer's workshop, nor are they accounted for in the few remaining lists of contents for workshops recorded in medieval wills.

For the armourer who doesn't possess a forge, an oxyacetylene torch can suffice. Using a rosebud torch, as much of the piece as possible is heated to an even, cherry red and allowed to cool. Placing the piece on a bed of firebricks will help somewhat.

The resulting anneal will soften the metal to a degree, and though it won't be even by modern standards, the metal's stress will be greatly lessened and work may progress.

HEAT-TREATING BY QUENCHING

During the 14th century, it is clear that armourers producing bascinets attempted to heat-treat by quenching in water or slack-quenching in oil. Unfortunately, given that many medieval bascinets were made from wrought iron or low-carbon steel, such treatments had no effect on their hardness.[4]

A piece should be heat-treated before grinding is done, since the grinding phase will remove the firescale that results. To roughly heat-treat a piece, it is heated to the critical range and then quenched in water, oil, urine, or other liquids. The armourer can use a tub made from half a barrel for this, though medieval armourers may have used large lead or stone cisterns that were often built into the workshop.

A more precise heat-treat can be obtained in a kiln. Several manufacturers in the United States and Great Britain make small kilns appropriate for the armourer's workshop. To get started the armourer can use a large ceramist's kiln, although front-loading versions are difficult to come by. New heat-treat kilns retail in the $2,000 range but are well worth the money. Paragon Kiln of Dallas, Texas, makes several, though only the largest (the HT-22, shown in fig. 19.3) is big enough for breastplates and helmets. The reward for purchasing such a kiln is precise control over the temperatures for heat-treating, drawing, and annealing.

Some armourers send their heat-treating work out to a commercial house that can monitor oven temperature precisely and quench in an optimal fashion for the specific metal used.

One important problem that must be overcome is the twisting that sheet metal undergoes during heating and rapid cooling. This twisting is the result of uneven working; if a helmet is unevenly raised from a cone using a gentle spiral in a clockwise manner, then the

Table 19.1—Critical temperatures for medium and high carbon steels

METAL	MODERN NOTATION	HARDENING	ANNEALING	DRAWING RANGE[5]
Medium-carbon	1050	1475–1550°	1400–1500°	600°
Medium-carbon	1065	1475–1550°	1400–1500°	700°
Medium-carbon	1075	1475–1550°	1400–1500°	800°
High-carbon	1095	1475–1550°	1400–1500°	800°

final piece will generally twist in the same direction during heat-treating.

The solution to this problem is to brace the piece with rods placed at strategic points. A bascinet, for instance, should be braced along the bottom edge and across the face. Convenient holes pierced for the vervelles can be and probably were used by medieval armourers for this, since no extra holes are found on extant medieval examples. For a breastplate, a cross arrangement can be used to insure that twisting does not occur. Poleyns and couters can be braced using the articulation holes, while cuisses and greaves can be reinforced in holes that will eventually be used for strapping. A single rod across the leading edge of the metacarpal will suffice for gauntlets.

SLACK QUENCHING

"Full" quenching as described above involves the violent formation of a nearly all-martensite crystalline structure. Unfortunately, the result is exceedingly brittle and subject to possible cracking during the quenching process itself or even under impact afterward.

It is likely that prior to the late 15th century, armourers quenched their pieces in liquids other than water to slow the process a bit and reduce the violence, providing greater impact strength while giving up some of the hardness. Precisely how medieval armourers "slack" quenched their projects was probably a jealously guarded secret—many 16th century formulae exist that recommend quenching in oil, lead, blood, urine, and just about any other liquid you can think of.

The modern practice is to avoid slack-quenching because it is imprecise; rather, medium-carbon steels are hardened and strengthened in two separate steps, a method that seems to have been in use in Germany during the late 15th century. (Milanese armour of the 15th century is largely harder than the German, and the evidence seems to indicate that the armourers of Milan were better at slack-quenching their armour than their German counterparts until about 1500, when the use of medium-carbon steel in Italy inexplicably disappeared in favor of low-carbon steels or iron).[5]

TEMPERING

When a metal has been hardened through heating quenching and subsequent tempering (a second, slow reheating for a specified time in its critical range), it is quite hard but is also strong. It resists movement and will also resist punctures. Metal that is hardened and not tempered is very brittle, however, and may shatter under strong impact.

Arrows and crossbow bolts, perhaps the most deadly weapons of the 14th century, would have had a hard time penetrating plate armour that was formed and heat-treated. Even in the event that one did pierce an armoured component, it would be unlikely to hit with enough force to shatter the plate itself. There is little evidence that 14th century armourers tempered their armour to trade some of the hardness for toughness, although no nondestructive test has yet been devised to test a metal's toughness.[6] As the 15th century progressed and missiles were increasingly propelled by gunpowder, they gained enough energy to potentially shatter breastplates, helmets, and other defenses if they remained brittle from the heat-treat.

Tempering steel reduces the brittleness while preserving the strength. A tempered metal will spring and move under impact, distributing the force and crumpling rather than giving and shattering.

Steels can be tempered by reheating them under carefully controlled conditions. Generally this gentle reheating takes several hours and must be done with some precision or the hardness will be lost. The finest of the German armourers of the 15th century—the Helmschmid family—produced work that shows evidence of highly proficient tempering technique. There is little evidence that Italian armourers possessed similar technology during the same period,[7] although it seems to have become far more universal during the 16th century.

Most modern armourers of my acquaintance who do heat-treating use the tempering method,

generally within the controlled heat of a modern kiln. The metal is first heated to the straw-yellow range and quenched, most often in water but sometimes in other substances such as oil. It is allowed to cool somewhat and then put back in the kiln and reheated to its critical range for approximately one hour and allowed to slowly cool again.

PRACTICAL HEAT TREATMENT

The technique used by modern armourers is a mixture of slack quenching and tempering.[8] The most common metals used by armourers who like to harden their work are 1050 or 1065. Shipped annealed, it works beautifully and a little more forgivingly than mild steel since it has less of a tendency to deform.

The metal is heated to its hardening temperature, somewhere between 1450–1550°F, at which point it is held at this temperature for no more than a few minutes. It is then removed from the heat (use care—at this temperature it can easily warp just by handling) and quenched in a medium-weight oil. Transmission fluid is the favored oil because it is both gentler to the steel (a form of slack-quenching) and the flash-flame that occurs during the process extinguishes as soon as the piece is completely immersed.

At this point the material is very brittle and must be handled with extreme care. As soon as it is cool it should be drawn to reduce the risk of damage, this time to a temperature between 400–700°F. Anywhere in this range will result in a piece that is both hard enough and tough enough to withstand even the most punishing reenactment use. A hotter draw will result in a piece that is less likely to crack but is more susceptible to damage.

Figure 19.3 The Paragon HT-22 heat-treating kiln. This is an exceptional kiln for the money, the built-in temperature regulator making precise temperature control far more convenient than treating done in a ceramics kiln (a viable low-cost alternative) or over a forge.

HAMMER HARDENING

Wrought iron and low-carbon steels cannot be heat-treated in their natural state. There is not enough carbon to trigger the hardening process, although they can be hardened from the hammer. There is little metallurgical evidence that this is an authentic treatment,[9] but it is often used by intermediate reenactor armourers who seek to provide a bit more durability for equipment that is to be used week in and week out.

Hammer-hardening is accomplished precisely as is planishing—the piece is worked over with a smooth-faced hammer. Moving in a systematic fashion, the metal is work-hardened over the entire surface, and the resulting resistance will help it to stand up under the stress of reenactment combat.

There are several reasons for hammer-hardening a piece. First, the cost is a fraction of what a medium-carbon steel plus heat-treating would cost. No cross-bracing is required, and the piece can be quickly finished. The planishing needed also provides a very fine finish on the armour's surface, which will make final finishing easier.

CASE-CARBURIZATION

Beyond hammer-hardening, which is only marginally effective, wrought iron or

mild steels may be improved by a complicated process known as case-carburization. In this process, charcoal is wrapped around the piece's surface and it is heated to the critical range. The carbon monoxide given off during the heating bonds with the armour's surface, creating a thin layer of steel that can then be heat-treated and/or tempered in the usual fashion, improving it by creating a thin shell of hard steel while preserving the toughness of the underlying mild steel or wrought iron. There is evidence of such case-carburization as early as the late 14th century,[10] and it was outlined by Theophilus in the 12th:[11]

"When they [the files] have been incised with a hammer and chisel, smear them with an old hog's lard, bind them round with straps cut from goatskin, and tie them up. . . . cover each one with kneaded clay, leaving the handles bare. When they are dry, put them in a fire and blow vigorously until the skin is burnt. Then remove them quickly from the clay, quench them evenly in water, withdraw them and dry them at the fire."

Both Italian and German armourers seem to have been aware of the process, though it was not used except in rare cases, at least according to the corpus of metallurgical evidence compiled thus far.

Commercial case-carburization pastes are available from welding supply houses, but I have not yet experimented with them.

WHERE TO GO FOR MORE INFORMATION

Heat-treating of the finished work is perhaps the most neglected component of reenactor armour reproductions. Beyond the information given above, there are several scholars who have conducted important studies in the field and who have written copiously on the topic since the early 1970s.

Specific heat treatments are spelled out in the metals handbooks available from many steel supply houses. A knowledgeable sales representative can provide a host of key information, including the possible location of companies capable of handling batches of armour for treatment. Generally speaking, the novelty of the work will interest the folks at the heat-treating house, so sometimes good pricing can be obtained.

Modern techniques for hardening steel have moved far beyond what was known in the Middle Ages and Renaissance. The temperatures can now be far more controlled, and the alloys used are known with precision, characteristics for each commercial alloy precisely charted. The latest in cryohardening techniques may also present some avenues for curious experimentation, although it will be interesting to see how near the medieval result the new technological approaches will be able to get.

ENDNOTES

1 See Dr. Williams' article in Chapter 8.
2 Source: *Admiral Steel Buyer's Guide & Reference Book*, 1998.
3 To Rockwell Hardness 45; properties of each steel vary at this number.
4 It is puzzling that such treatments would have been done if they had no effect on the armour. Two possibilities seem to exist: that the armourers did not know enough about the materials and processes to know that steel rather than iron was required, or they treated the pieces knowing it had no effect but for some other—possibly commercial—reason. It is also possible that the effects of the treatment either don't show up in terms of the hardness testing or metallurgical analysis, or that the effects have changed over time.
5 Williams, Alan, and Anthony de Reuck. "The Royal Armoury at Greenwich 1515–1649: A history of its technology." Royal Armouries Monograph, 1995. Figure 2, p. 25.
6 De Reuck, Anthony. "The Armourer's Dilemma: Hard versus Tough." *Royal Armouries Yearbook*, Vol. 2, 1997, p. 73.
7 Monnich, Theodore. "Iron and Steel in the Making of Armour." *Chronique* #13, 1996, pp. 45–56.
8 T. Wise, personal correspondence.
9 Dr. Alan Williams, personal correspondence.
10 Dr. Alan Williams, *Waffen and Kostumkunde*, p. 93.
11 Theophilus, *On Divers Arts*, p. 94.

Figure 20.1. The joinery and fitting of the individual plates with one another is one of the most arcane of the armourer's skills. Plates move both on internal leathers and against other plates to accomplish smooth movements that give a finely wrought medieval harness surprising mobility. On this pair of late 15th century legharness, now in the Wallace Collection (A290), two different joints are present — one at the knee and one at the hip. Each has a different set of requirements in terms of mobility and durability, so each is joined using different techniques.

The knees are joined by what I call a "shell" articulation, and it is apparent that the original rivets were put in without washers (I suspect that the single washer pictured is a repair, a useful trick when a hole has become enlarged through wear). In the German fashion, two lames are used at the top, but the lower lame(s) are missing. A hole remains in the poleyn itself for a strap extending behind the knee. One additional strap mounting point is evident on the cuisse itself.

At the hip, the lames are pivoted on the outside but are on sliding rivets on the inside. The use of a floating joint with a leather binding yields great flexibility that would have allowed the knight to bend at the waist without hindrance. On the backflap, however, the lames are held in place with sliding rivets at the back but leathers at the center. Notice that there is an arming point along the top edge of the cuisse for lacing the harness to the pourpoint or arming coat. Being done in the German style, the harness is relatively light, weighing in at just 2 pounds 9 ounces. These striking detail photographs also show the very rough texture characteristic of many medieval pieces, the main evidence that leads the author to believe that medieval armourers often ground away a good deal of material. (Photo courtesy of the Trustees of the Wallace Collection.)

Chapter 20

Engineering the Joint

One of the medieval armourer's greatest achievements was the wonder created by a fine harness's engineering. A good harness was a sleek, well-fitting, good-looking defense for the body that would protect even as it allowed the knight to maximize his offense, whether mounted or on foot. The art of creating smooth, effective, ergonomically friendly joints is referred to as "articulation." Plates are "articulated" with one another, a combination of skillful forming and attachment techniques that yield a joint.

Fortunately for the modern armourer, the techniques used by the medieval armourer to solve the movement problems are well-documented through existing pieces and highly detailed funerary monuments. The modern armourer should strive to use techniques appropriate to the piece in question rather than trying to "improve" these well-thought-out defenses.

TYPES OF ARTICULATION

There are four main ways to join plates to one another in order to provide movement.

First, there is the floating joint articulation, where the plates are affixed to one another through leather strapping, cloth lining, or with laces.

Figure 20.2 Evolution of the plate joint. In the Fitzralph effigy (left), c. 1320, from Pebmarsh Church, England, the use of very simple plate or cuirbouille augmentations to the mail are clearly shown on the elbows and along the length of the legs. The joinery of the plates at the shoulder, arm, and leg is likely accomplished using "floating" joints with a leather binding rather than through the later and more rigid plate to plate attachment. By the end of the 14th century, shown here in the brass of Sir John de St. Quintin (center), we can see that full plate defenses have already evolved. Here only the shoulders and possibly the sabatons are still constructed using the floating joint technique. The elbow and knee joints are now defended by the more advanced shell articulations that rely on lames to affix the couter and poleyn to the respective limb defenses for arm, thigh, and shin. By the middle of the 15th century, represented here with the effigy of Sir Robert Staunton (right), c. 1453, notice that although the use of plate defenses is complete and reinforces have been added, the construction of the joints has not changed appreciably. Here, floating joint defenses have been supplanted completely by shell and stepped articulations, even in the shoulders and with the sabatons. The huge wrappers at the elbow are likely attached with pins over an arm harness not appreciably different from the one used by Sir John 60 years earlier.

Second, shell articulations are used chiefly where the metal must expand as the joint is opened, as with the couter or poleyn. In such joints the pivot plate will be on the outside, forming the shell.

Third, stepped articulations are used where the metal's surface area must contract with movement, as in the lames of the pauldron, gauntlet, fauld, or sabaton. Pivot plates, when they exist, are generally on the inside, as in the case of the sabaton or a 16th century gauntlet.

Lastly, channel articulations allow for sliding movement for one cylinder inside of another, as in the rerebrace or gorgets. Techniques for this last form will not be addressed here since they apply only to harnesses of the 16th–17th centuries.

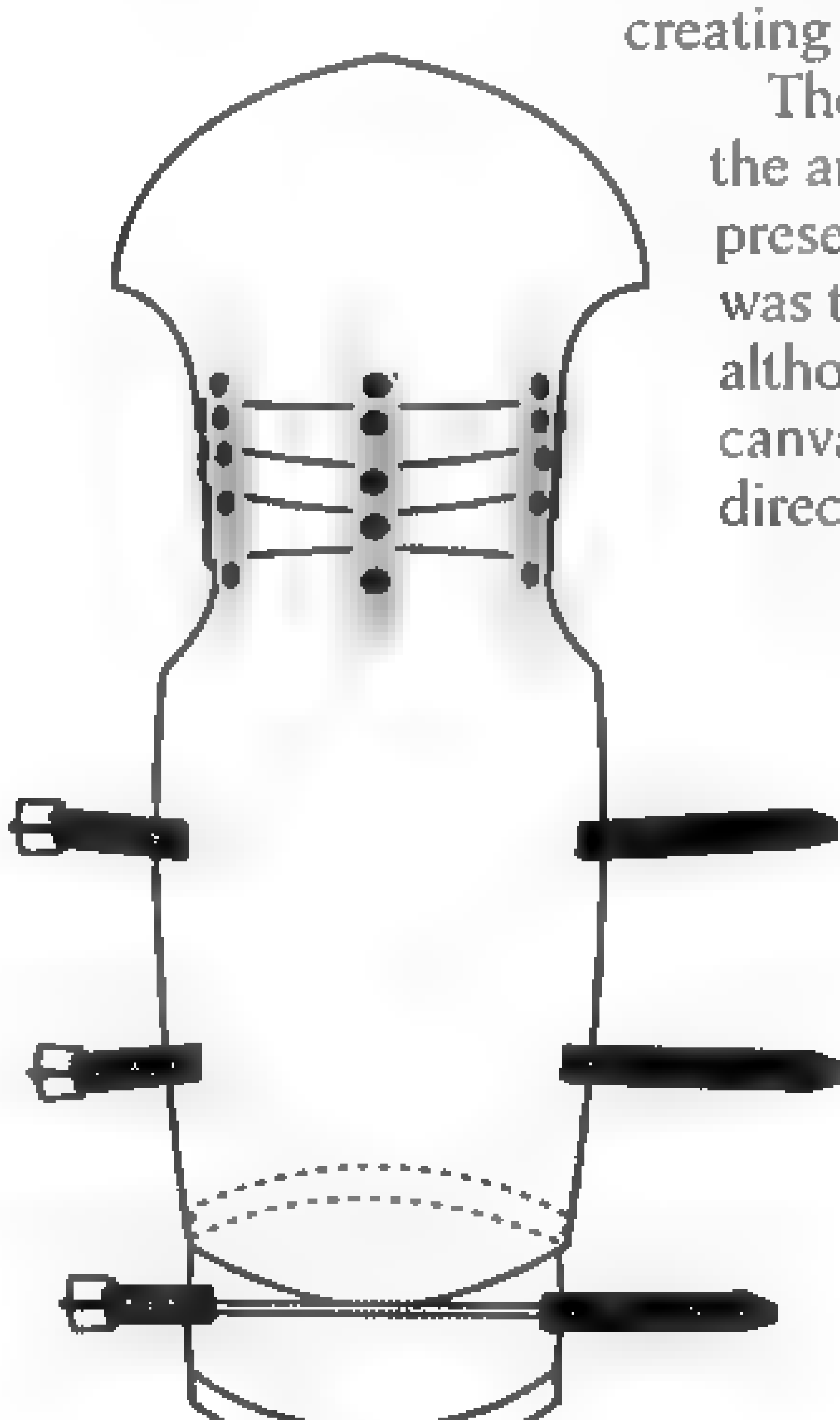


Figure 20.3. The brass of Sir Miles Stapleton, from Ingham Church, Yorkshire. Note the floating arm defenses and poleyns attached with a line of rivets to the cuisses and leather greaves. At right, a reconstruction of the arm defense (sans vambrace). The spaulder cop, lames, and rerebrace are affixed using leather straps and broad-headed rivets. This leather binding holds the components in place while allowing for a great deal of flexibility. Based on the position of the plates on the figure's right arm, the couter appears to float freely without being attached to the rerebrace, although it could be attached to the vambrace with straps. The use of leather to bind plates together—especially on the limbs—remained an option for the armourer into the 17th century.

FLOATING JOINT ARTICULATION

The earliest arm and leg defenses seem to have consisted of cuirboille poleyns, couters, greaves, vambraces, rerebraces, and cuisses. Sometimes these cuisses were made from brigandine or padded material, as shown in Figure 20.3, while others seem to have been made from iron plate or cuirboille. The first reinforces were not attached to one another but were instead simply laced to the mail itself. As plate defenses came into use, flexible materials were first used to attach plates together, creating the floating joint articulation.

The use of a flexible binding agent allows the armourer to hold plates in position while preserving a great deal of mobility. Leather was the most common materials used, although early cuisses of padded linen, canvas, or wool could have been laced directly to the poleyn, relying both on the soft material and the flex of the tie to provide the necessary movement.

Starting in the late 14th century, many of these defenses on the finer harnesses were replaced with shell articulations described below, especially at the knee and elbow joints. During this period, shoulder defenses were probably joined with flexible leather straps run along the lames and attaching to the rerebrace (fig. 20.3). During the 15th century the rear strap was sometimes replaced with a sliding rivet, the leather providing mobility in the forward direction where it was needed most and the rivets at the back providing an increased measure of rigidity.

Legharnesses seem to have evolved more quickly, because the relatively rapid adoption of

reinforcement for the thigh and knee required some form of interaction between the plates. Since early cuisses were created from flexible material, direct attachment of the poleyn to the cuisse would have yielded expedient results. Shell articulations for the knee probably came into use during the 1350–1360s, although the older form seems to have been in use—at least in England—throughout the century. The development of the plate cuisse may well have driven the development of the shell articulation, and it is likely that such technological advances came from the Italian workshops, where plate armour for the limbs proceeded ahead of the rest of the continent.

Floating Articulation Theory

For the novice or early intermediate armourer, floating joint articulations are easy to construct and maintain without the expertise necessary for more advanced fixed-point joints. Fortunately, they are also appropriate for harnesses throughout the 14th century and into the 15th so there is plenty of variety to get started with.

For limbs, each "gutteral" defense pair (the lower and upper arm and the cuisse/greave) is shaped so that they almost touch (fig. 20.5a). A cop then covers the joint itself, connected with laces through to the arming garment or bound together with strapping (both techniques were probably used). For the arm harness, the couter appears to have sometimes floated freely (fig. 20.5a), while in floating arm defenses of the 15 century the couter is affixed to both vambrace and rerebrace as in Figure 20.5b.

The shape of the plates is generally far less critical with floating articulations than it is with shell or stepped articulations. Early poleyns and couters were often large and flared at the edges to fit snugly against the gutter-shaped defenses for the limb (fig. 20.6). Note that no historical examples survive, probably owing to the deterioration of the binding leathers. The remaining references are from manuscript illustrations and funerary effigies, and it is probable that many of the defenses pictured were made from cuirboille rather than from iron. (Working in hardened leather is explained in Chapter 27.)

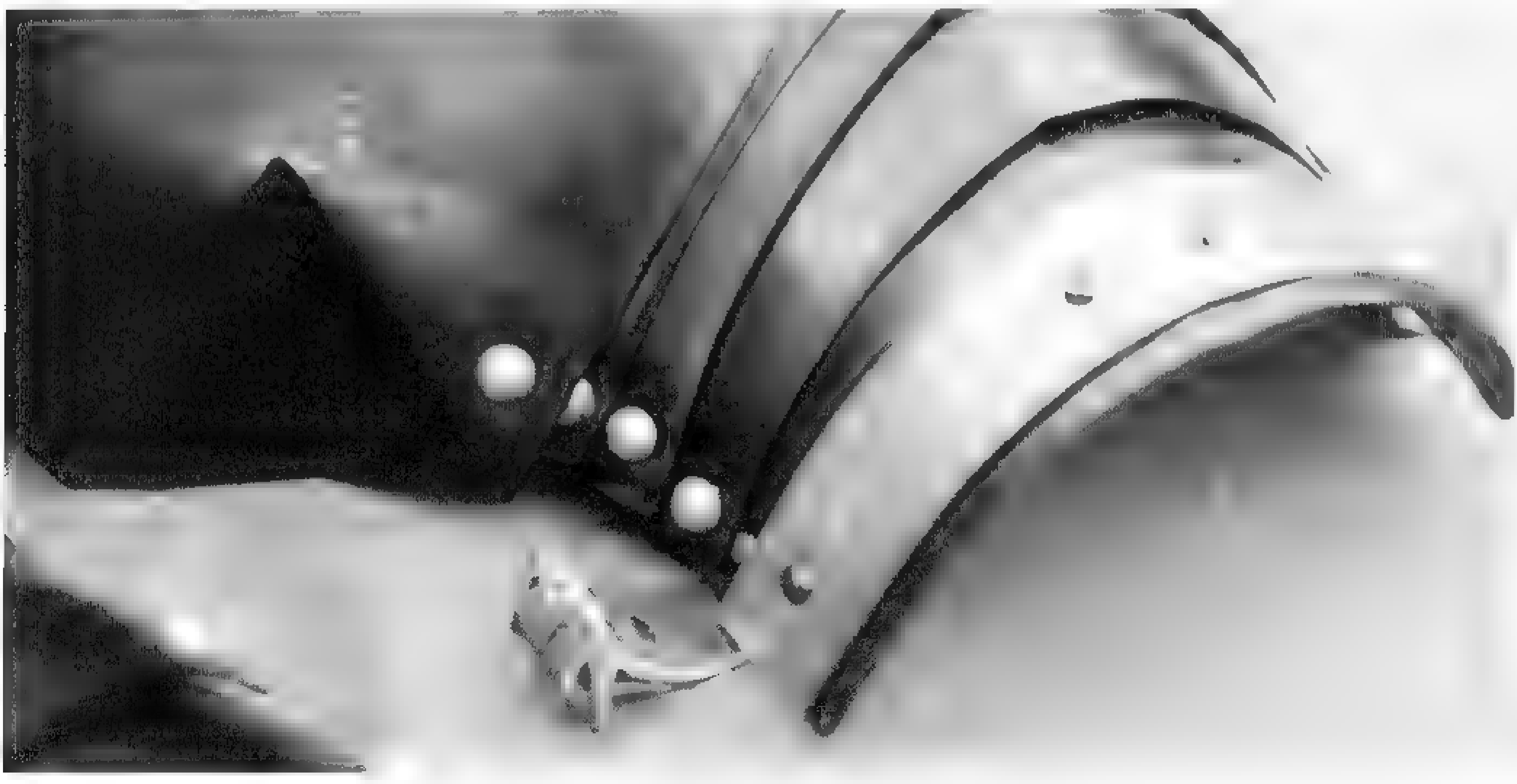


Figure 20.4 Range of motion is critical in the creation of a spaulder. Since the shoulder pivots over a wide surface area, leather binding straps offer an excellent solution, though with less durability that can be had from more direct methods. On the 15th century munitions spaulder above, done by the author in 1992, notice how the plates collapse under one another to compress enough to create mobility.

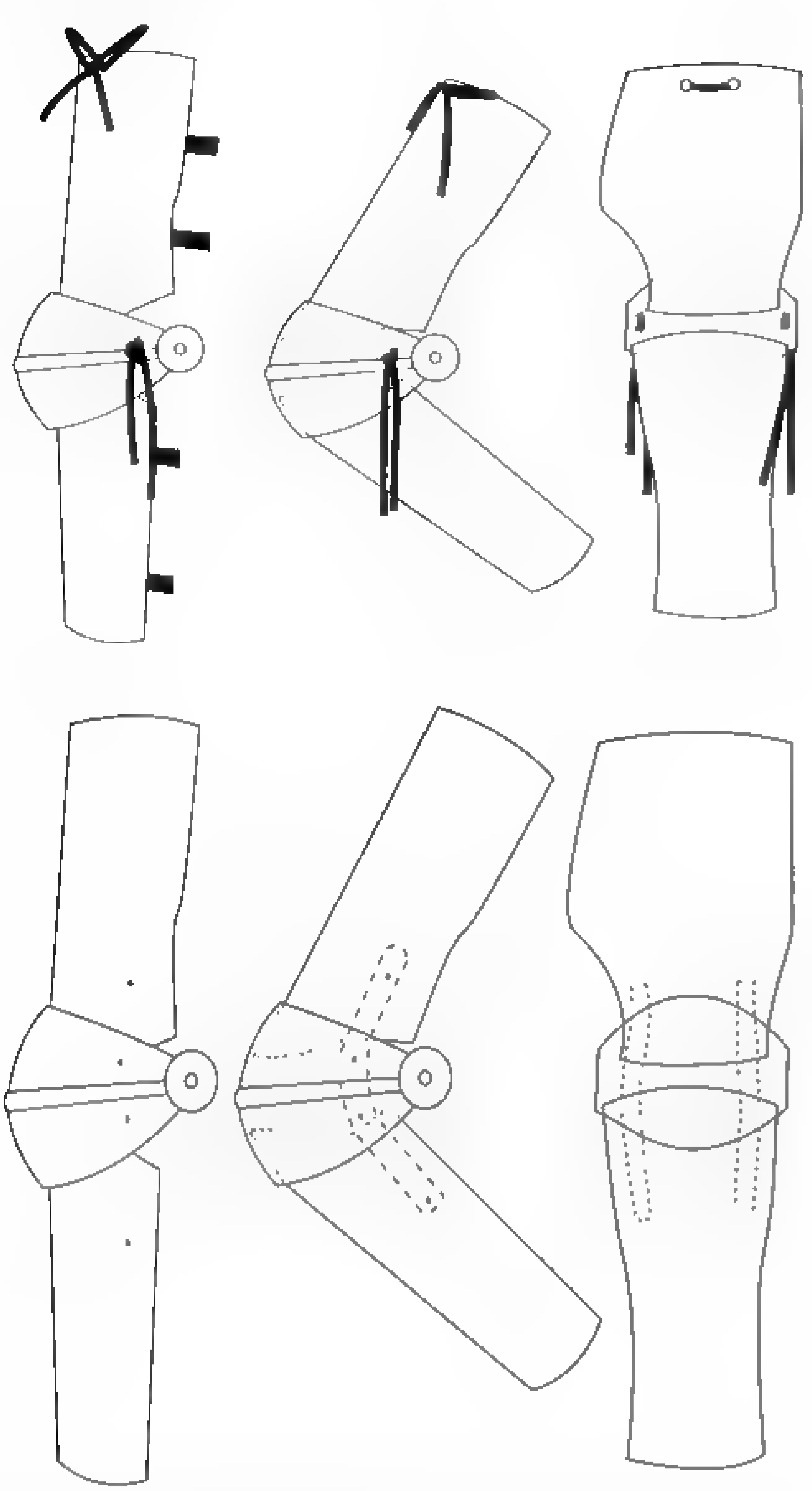


Figure 20.5. Two interpretations of floating articulation schemes based on an early 14th century stained glass figure depicting one of the Lords of the Manor from Tewkesbury.[1] The original figure does not detail laces or rivet placements, so the above examples are intended to show different ways that the floating joints might be articulated. (A) is based on the laced joint, probably the earliest technique employed to maintain plate position in a joint. The laces would pass through the mail or arming coat, each plate riding independently from one another. (B) is an interpretation based on extant 15th century arm harnesses where two leather straps attach the components. Most 14th century arm harnesses prior to 1350 were probably done this way until the introduction of the shell articulation It is likely that the leather straps (shown as the dotted lines) would have been extended up to attach the rerebrace to a simple spaulder cop as well (fig. 20.3). Both would feature the straps shown in the straight version of example A; they are omitted in the remaining sketches for clarity

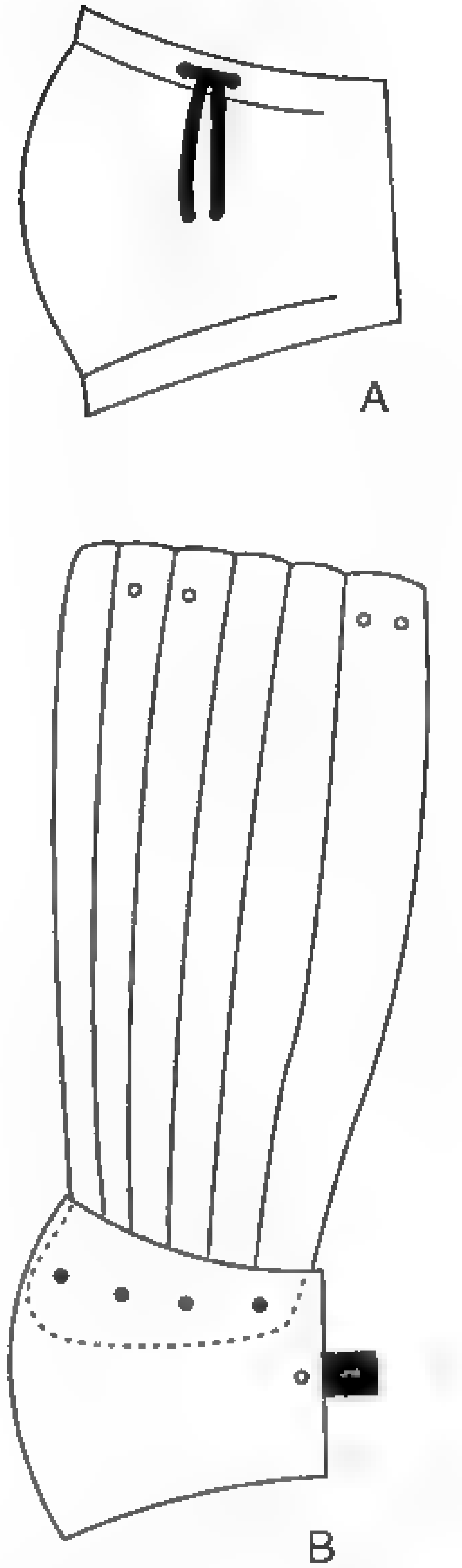


Figure 20.6. The first poleyns were large defenses that simply laced to the mail chausses, the necessary movement being provided by the flexible nature of the mail to which they were attached and the laces themselves. (A) represents a large poleyn that might have been used from 1330–1350. Made of cuirboille or metal, early poleyns reinforced the underlying mail defense by providing some rigidity. At some point during the middle of the century, the thigh defense was also augmented through the use of semiflexible cuisses made of quilted cloth (B) or reinforced leather. The cuisse, if extended to cover the knee itself, also provided a measure of padding Likely materials for the cuisse would have been a stiff canvas lightweight leather, or wool, any of which were probably stuffed with linen, horsehair, or wool. The poleyn in (B) above is based on the only extant defense from this period known to the author, Royal Armouries III.3220, acquired in 1989 Location of the rivet holes is speculative, as the author has not handled the original, though reconstructions based on these techniques have worked in combat conditions

For defense of the leg, poleyns can be attached directly to the cuisse for an expedient joint, although the lacing will tend to wear quickly. A more common technique seems to have been an attachment with multiple rivets to a flexible cuisse of leather or cloth, as can plainly be seen in Figure 20.6b.

Floating joints are most commonly employed in the shoulder joint (fig. 20.3b). In this style of construction, sometimes also used for sabatons and faulds,[2] the plates overlap one another from 1/4 to 3/4 inch and are bound together with leather strapping. The straps are generally formed from flexible but relatively thick leather from 1/16 to 1/8 inch thick. One or two broad-headed rivets are used, generally placed such that the rivet disappears under the plate above.[3] Surviving examples from the 15th and 16th centuries often use two smaller rivets in place of the larger one, but the function remains the same.

SHELL ARTICULATION

By the third quarter of the 14th century, full plate joints for the elbow and knee had been largely perfected through the use of what I call shell articulations. Perhaps the most difficult joint to engineer cleanly, this articulation expands the metal defense when the joint bends. It is used chiefly at the elbow and knee.

In a shell articulation, a central pivot plate—the couter or poleyn, generically its "shell"—sits prominently at the joint's apex and controls the movement of the lames, simultaneously hiding them as much as possible to protect them from blows. When straight, the plates are protected under the shell; when the joint bends, the underlying lames pivot to expand the arc started by the shell itself, just catching to define the maximum bend, a band approximately 3/16 to 1/4 inch of material defining the "arresting" point for the joint (fig. 20.8). The depth of the pivot plate, the placement of the rivets, and the number and dome of the lames determine the degree to which the joint bends. The joint should open as much as possible without gaps.

Although few historical examples of these joints remain from the transitional period, the techniques perfected over the second half of the 14th century remained largely unchanged as long as armour was worn.

Shell Articulations and the Knee

Early efforts to join a plate cuisse and poleyn seem to have relied on the floating joint technique or a line of rivets attaching the knee directly to the cuisse.[4] Plate cuisses seem to have come into use around 1350–1370.[5] At this time the poleyn was attached using a narrow lame affixing it to the cuisse (figs. 20.9b and 20.9c). In some examples the lame is omitted in favor of a raised bump at the end of the cuisse (fig. 20.9a). This odd technique was used throughout the 14th century and into the 15th. On the lower edge of the knee, another lame mirrored the top one, affixing sometimes to the greave itself while at other times to a sort of demi-plate that fit snugly with the greave, usually but not always with a pin or staple to hold it in place.

In these early iterations, two lames (one above, one below) seems to have been the normal construction technique, although there were variances, especially in how the upper lame was handled. It was not until the 15th century that the use of multiple lames on each side of the poleyn came into widespread use. The reason for the fashion remains a mystery, as these additional lames are not necessary to provide the full range of movement.

The lames were in turn attached directly to the cuisse and sometimes to the greave. In England at least, the fashion seemed to favor the insertion of a small demi-greave between the greave and lame, a technique that offers more mobility since the play between the loosely attached pieces yields a slightly larger range of motion.

Shell Articulations and the Arm Harness

As the couter evolved throughout the middle of the 14th century, it seems to have first been attached to the rerebrace alone, the vambrace possibly riding separately. Monumental brasses seem to support this

Figure 20.7 Although this legharness dates from the 16th century, its shell articulation is substantially the same solution as armourers developed in the 14th century. Each slightly domed lame provides a section of the required arc. Late period legharnesses – especially those of German manufacture – often used two lames above and two lames below. Earlier articulations generally used fewer lames. (Wallace accession A289–90, weight 2 pounds 9 ounces each. Photo courtesy of the Trustees of the Wallace Collection.)

theory; often the vambrace can be seen disappearing under the mail sleeve, while the rerebrace and couter rode over it.

Just after 1360, the armourers seem to have used the shell technique for arm defenses, quickly adopting the one-lame-per-side technique (fig. 20.10). Most of the joint's necessary range of motion can be accounted for with the couter itself since the elbow is sharper than the knee and is more easily raised into a compatible shape. This ease of manufacture offers a possible suggestion for the reason English brasses of the late 14th century often show a fully articulated arm harness with the older style poleyn and cuisse arrangement.

Early examples, such as the Black Prince's harness of 1376 or the Churburg arm of 1390, show a more pointed couter. The Black Prince's harness features the two-lame shell articulation while Churburg #13 actually uses two lames at the vambrace, although the second is fitted with three sliding rivets that allow the vambrace to slide from side to side rather than helping to increase the motion of the couter itself (fig. 20.19). This construction appears to be a high-end idiosyncrasy of the Milanese armourers. This basic function of the shell articulation for the arm did not change until 1500.

Most armourers working for reenactors tend to use overlarge, shallow poleyns. Because their clients must often kneel when fighting (an uncommon activity in medieval fighting), they must also allow for this movement. For this reason, armourers often use four or even six lames when creating a legharness, relying more on the loose fit between the pieces to account for the needed range of motion.

The other common flaw within the reenactment community is the use of flat lames. The lames themselves are rarely flat in the medieval originals; normally they are domed slightly and almost always strengthened with the characteristic central ridge used throughout the 14th and 15th centuries.

Shell Articulation Theory

To achieve the required range of motion with a shell articulation, the shape of the pivoting plate—the shell—and the placement of the rivets are the two critical factors.

The shape of the shell depends on the range of motion required and is crucial to the joint's success. When seen from the top (fig. 20.12), the shell's edge should form a smooth arc where

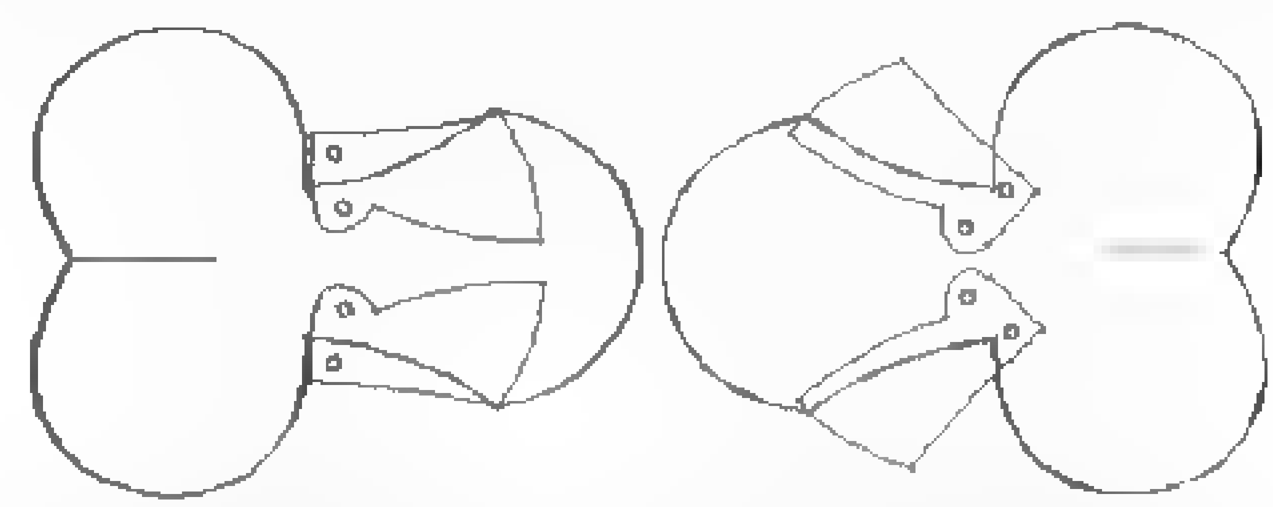


Figure 20.8. Sample shell articulation of the knee joint. In the straight position, left, the lames are hidden under the poleyn. When the articulation is extended around the circumference of the joint, the lames expand and increase the area covered by the knee defense.

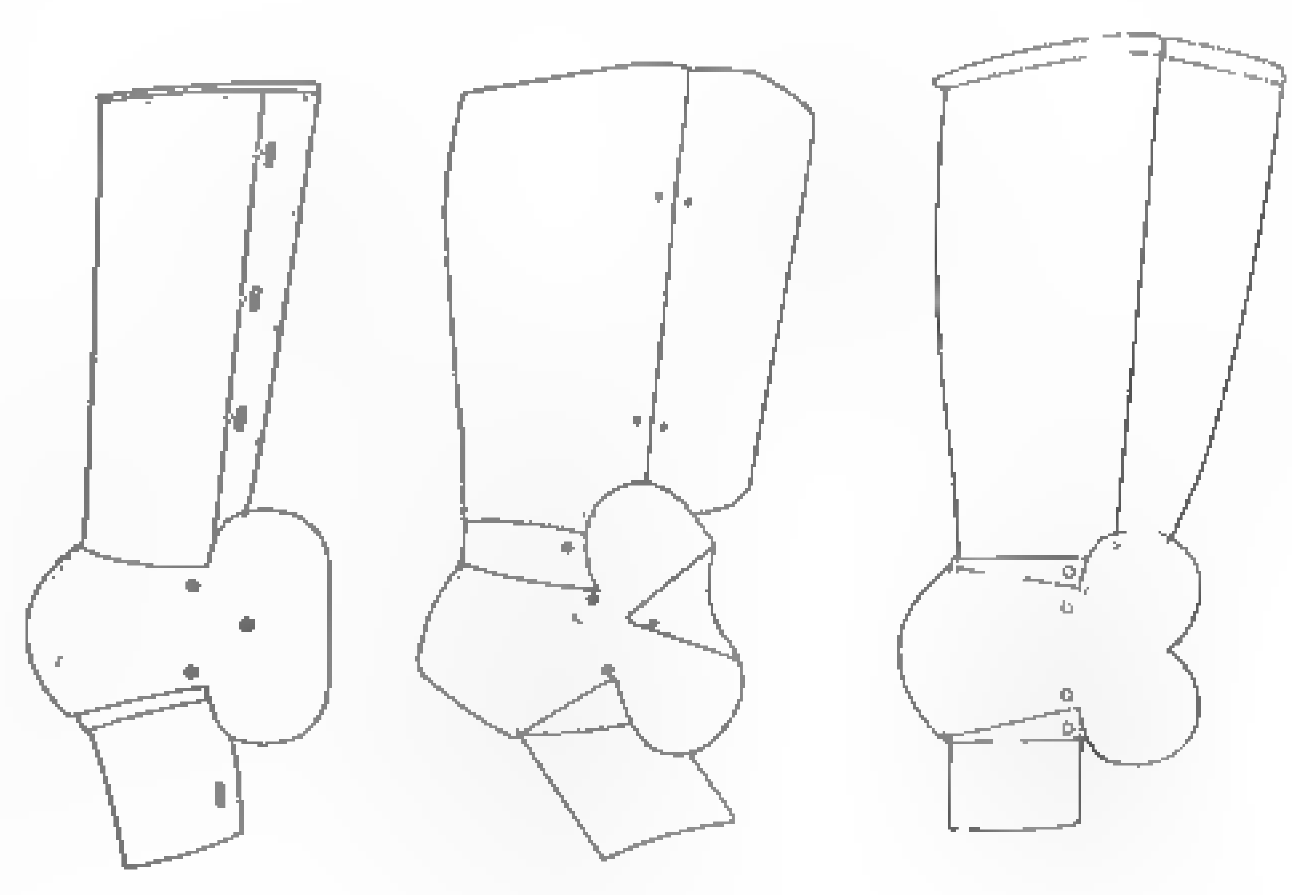


Figure 20.9. Three legharnesses of the 14th century joined using variants on the shell articulation. The first (A) is from elements of a child's harness preserved at Chartres Cathedral. The original also has a greave (not pictured). An unusual feature of this harness, shared by CH-54 at Churburg, is the lack of an upper lame. The poleyn is joined directly to the cuisse, which is raised to simulate the function of the upper lame without the extra plate being required. The second (B) was originally preserved at Churburg but is now in the Royal Armouries (III.1285-6—see fig. 34.1). This construction is also unusual, because the upper lame is attached under the cuisse. The more usual construction is represented not by an actual harness but by the leg defense sculpted into the Black Prince's effigy at Canturbury Cathedral (C). Here two lames nest smoothly and without gapping under the poleyn.

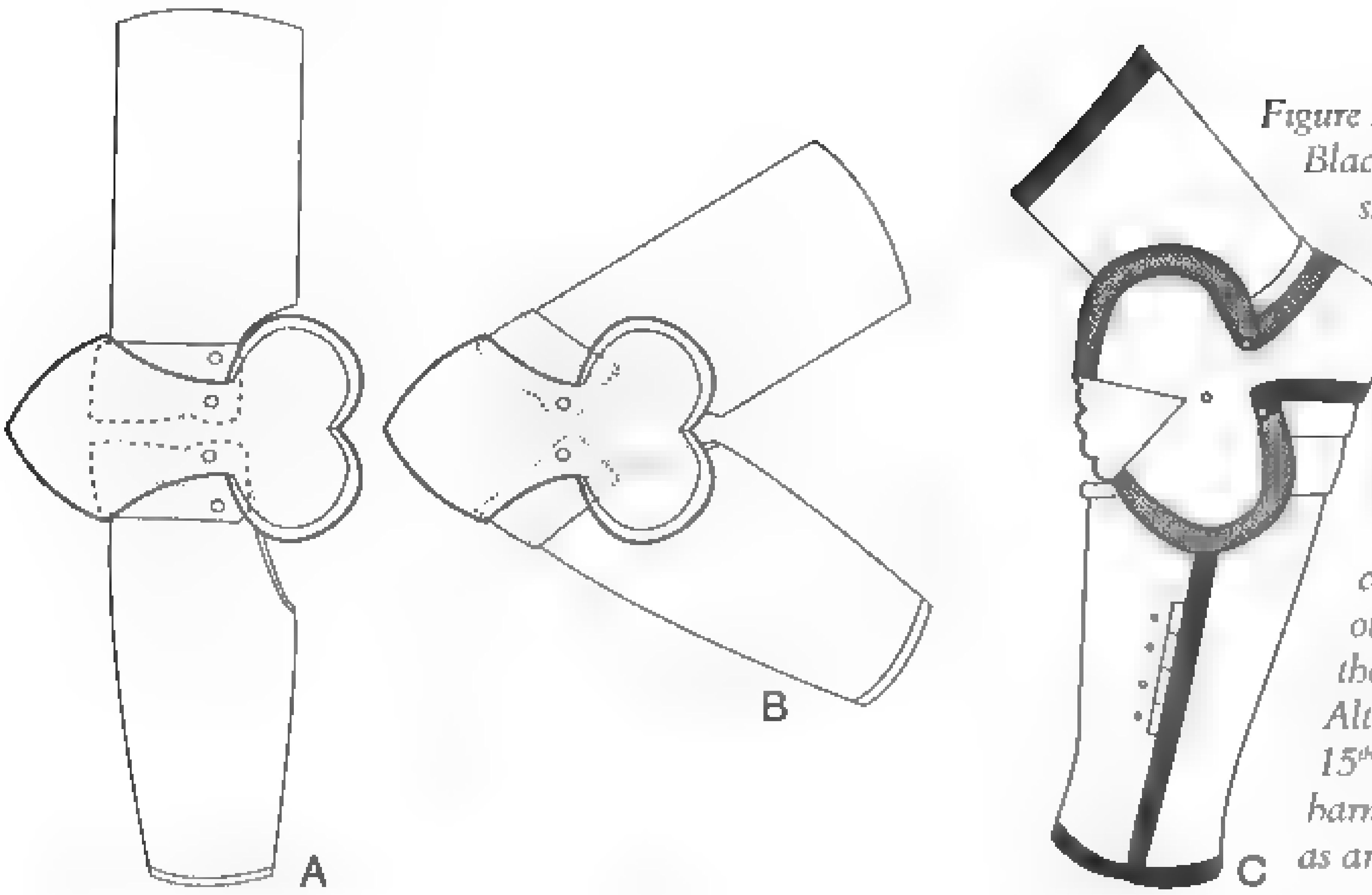
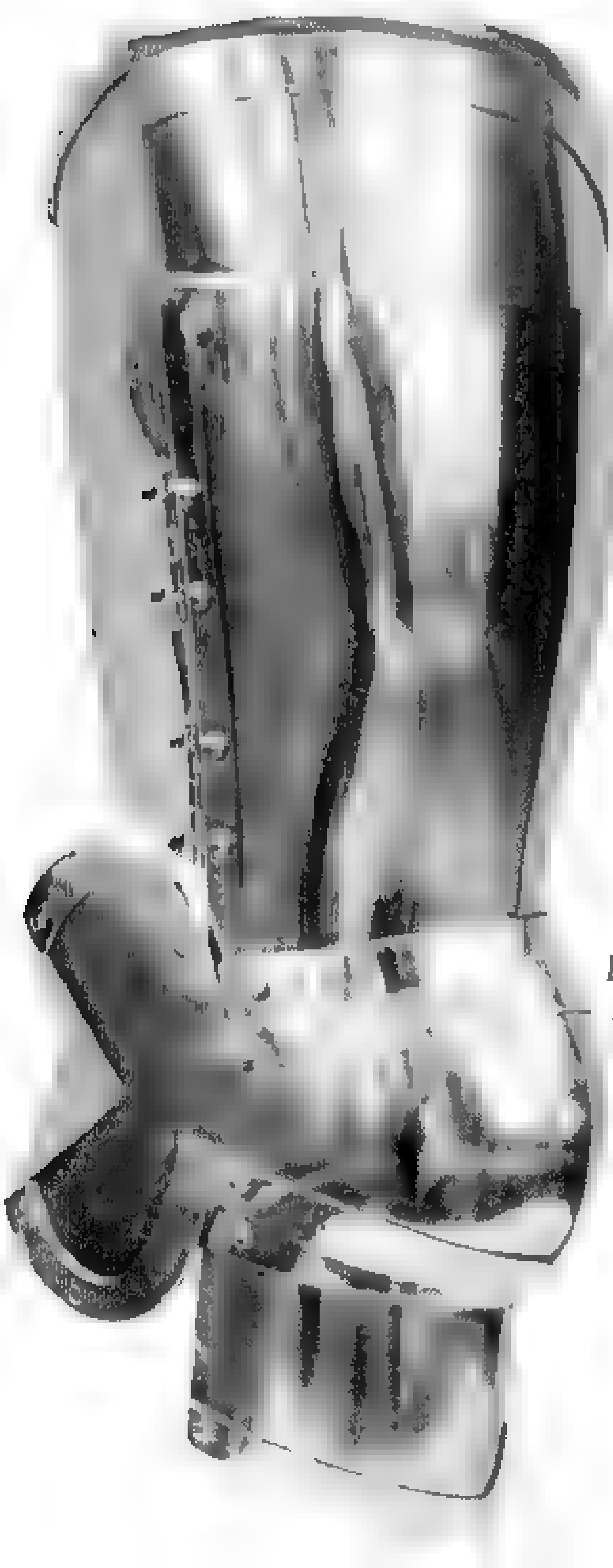


Figure 20.10 A 14th century arm harness from the Black Prince's effigy in Canterbury Cathedral showing the full range of motion possible with a simple shell articulation of two lames. The dotted lines represent the probable shape and placement of the portion of the lames hidden from view. (C) is traced from the Churburg #13 transitional armour. Note that although there are two lames on the vambrace, only the one closest to the couter contributes to the joint's bend while the other is fitted with three sliding rivets that allow the vambrace to slide from side to side. Although the style of the wing changed in the 15th and 16th centuries, the function of the arm harness remained essentially unchanged as long as armour was worn.



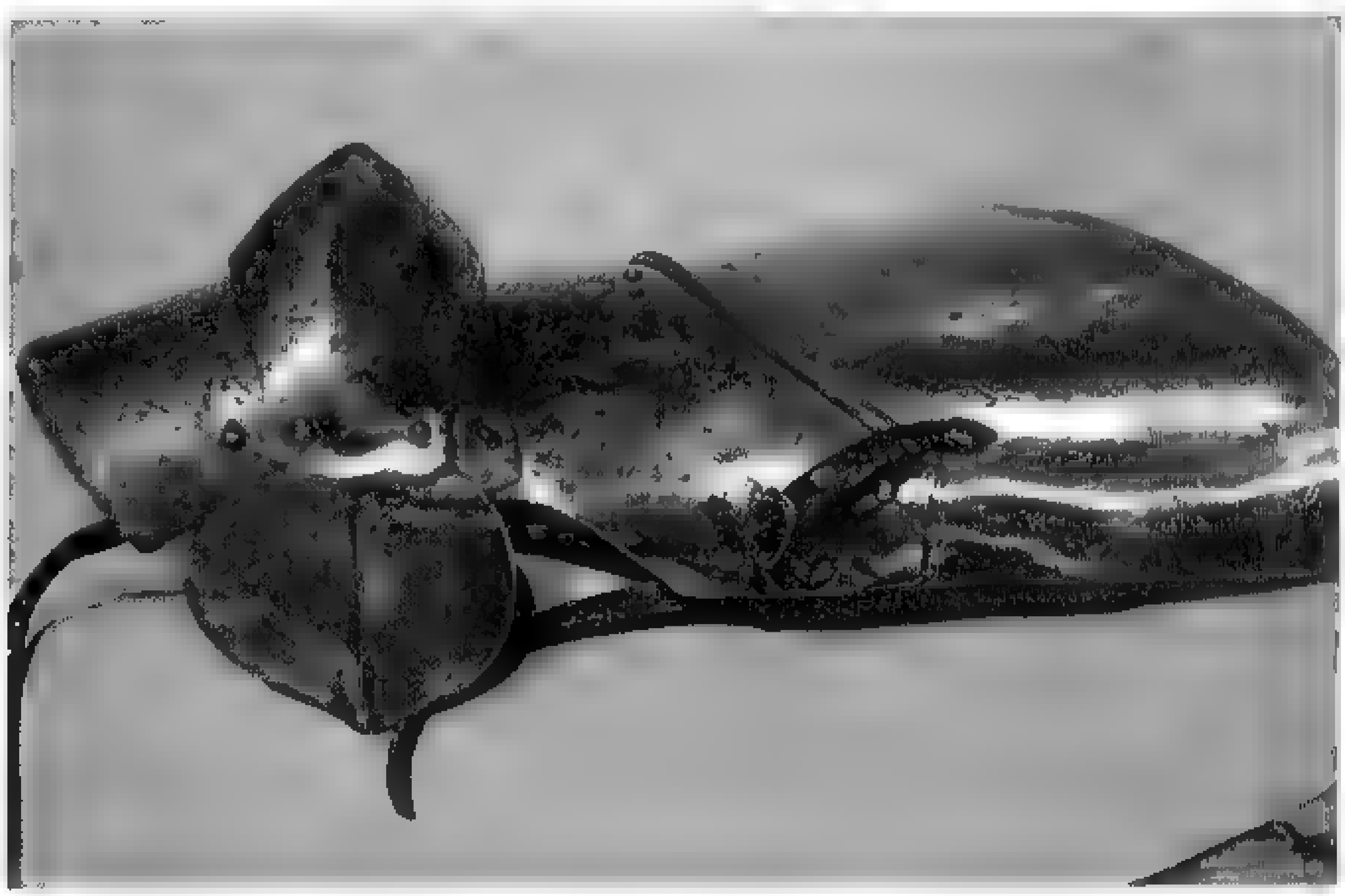


Figure 20.11 A more medieval legharness by Brent Junkins (left), modeled after the style of the late 14th century. Notice how the lames disappear almost completely under the poleyn, the lack of space between the plates, and how the strong central ridge defines the shape of the harness while increasing the strength of each piece. Compare this with the more typical munitions harness (above) often adopted for reenactment use. Notice the large poleyn and the large number of lames. It bends sufficiently to allow the combatant to kneel completely, but the lames are exposed to blows and deform easily.

the pivot points spring nearly opposite and parallel to one another. This applies equally to couters or poleyns, and it is not always the case on the medieval originals, though joints that lack this element tend to offer less movement. Poleyns are frequently strengthened with a central ridge; when seen from the top they are reminiscent of the arch shape so popular on transitional harness elements.

Couters are generally conical in shape, while poleyns tend to be more rounded to account for the large size of the knee itself. Placement of the rivets on the pivot plate is also important. They should never be closer than 1/4 inch from the metal's edge. I tend to place them approximately 3/8 inch from the edge on legharnesses.

A common error is to attempt a shell articulation with a poleyn or couter that is not deep enough to permit the required motion. Looking at authentic examples in profile, one can immediately detect that many of the joints have been deeply domed, usually by raising since dishing to this depth will thin the metal excessively. Reenactment armourers sometimes weld poleyns or couters in halves to achieve the depth without the required raising, a practice that yields good articulations and an authentic appearance even if the technique itself is modern.

When seen in profile, the shell should account for most of the required range of motion (fig. 20.8). The rest will be provided by the lames and small gaps between the plates. Shallower shells will either permit less movement or will require more lames to achieve the required range of motion.

Although simply curled flat lames can be used, this reduces the flex available in the joint. The lames should be slightly domed and shaped to fit just inside the shell. It is important that the lames rest without stress alongside the shell where the rivets will be placed; otherwise the tension will either bind the joint or tear the metal.

To articulate a shell joint, first fit either lame to the inside of the shell, leaving approximately 1/8 inch of material along the outer edge and the top of the lame just intersecting the top of the shell (fig. 20.13.1). Punch a hole in the lame at the appropriate point and set the lame temporarily in place using a 3/16 inch bolt.

To determine the placement of the hole on the wing side, three arcs must be drawn. Using a marking pen, run a line parallel to the edge of the lame approximately 1/4 to 3/8 inch from the edge of the pivot's edge (fig. 20.13.2).

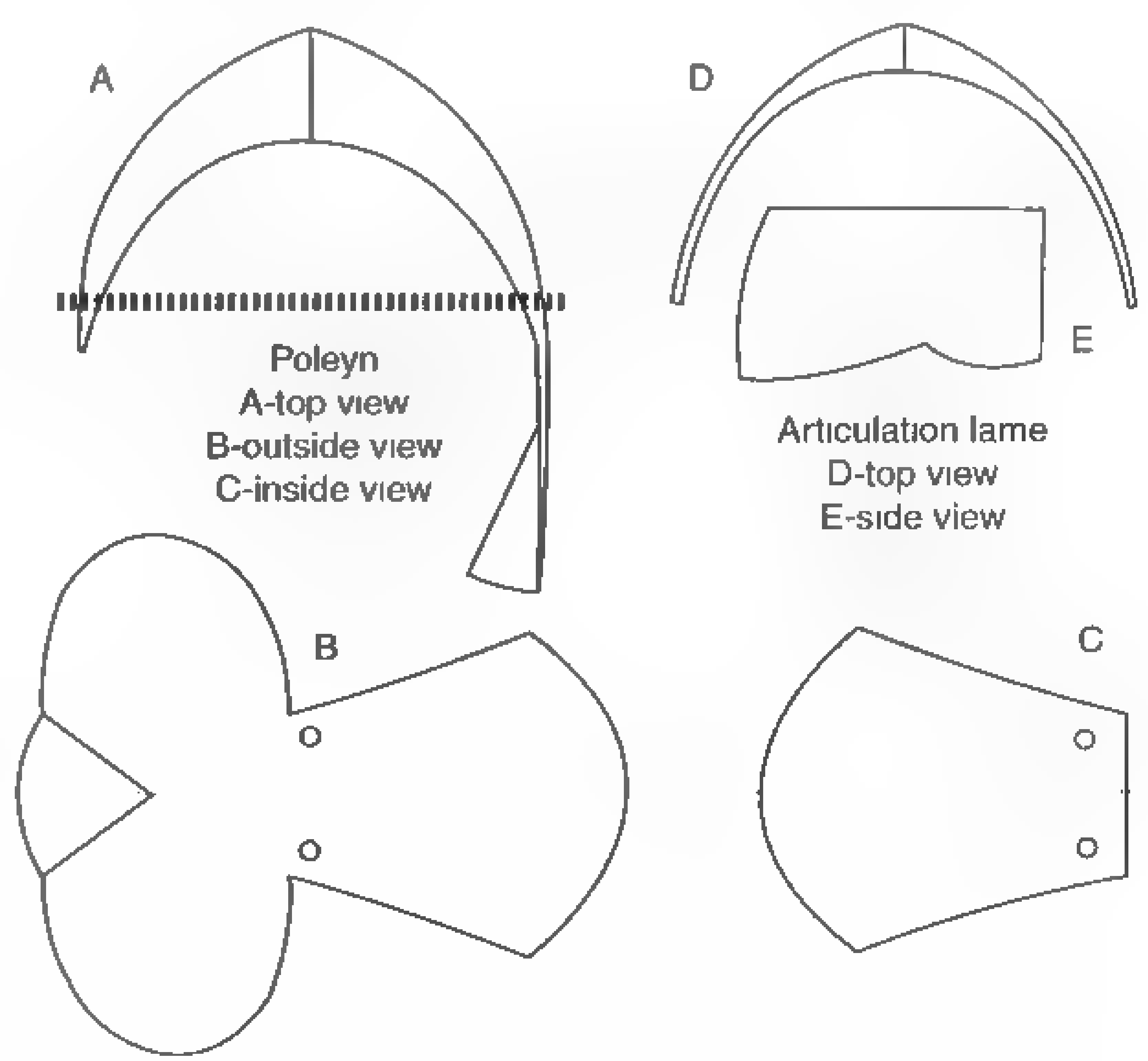


Figure 20.12. The shape of the poleyn or couter in a shell articulation is critical. The shell must be deep enough to accommodate the required movement and be shaped properly at the edges to permit the placement of articulation points where they will be as parallel as possible. The lames must also be shaped correctly, nesting smoothly under the shell, close but without tension where the rivets will eventually be placed. These shaping parameters apply equally to elbows or knees.

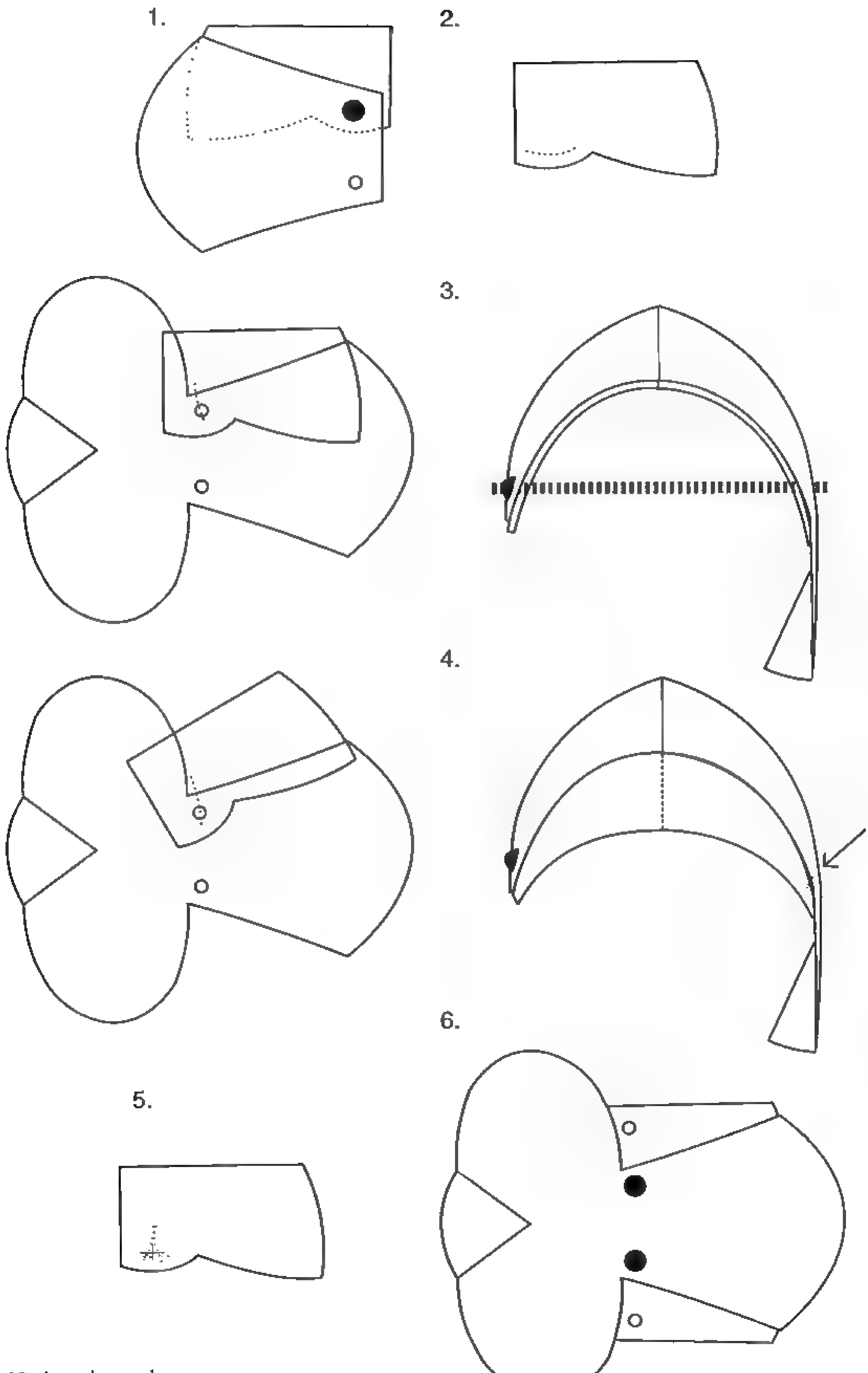


Figure 20 13 Articulation theory

Next, position the lame so that it is in an appropriate place when the limb is straight (fig. 20.13.3). It is important to keep the top edge parallel. The lame is now moved very slightly up and down, a marker creating a line at the wing-side articulation point. It is then moved to the open position (fig. 20.13.4) and another line marked it is lifted up and down slightly.

Removing the lame from the shell (fig. 20.13.5), there should now be three lines. Place a hole at the intersection of these three lines for the best hole placement.

Both lames are temporarily reattached to the shell with bolts and the holes placed for attachment of the cuisse and demi-greave. This should be done so that the holes line up or are at least reflections of one another (fig. 20.13.6). The cuisse or greave is now attached so that they allow perhaps 1/4 inch of movement between the cuisse and lame and so that there is at least 3/8 to 5/8 inch of material overlapping the lame.

If the shell is shaped correctly and the articulation points placed properly, the joint should move smoothly through a wide range of motion (fig. 20.14). If this is not the case, an additional lame can be added at the demi-greave or vambrace, but this should be avoided if possible as the lame is exposed and will eventually suffer damage in combat.

The rivets are loosely piened, but the holes should not be enlarged to provide more movement because this will allow the plates to slide, something which can cause the plates to gap. (See Chapter 17 for details on how to set an articulation rivet.)

The lames should not gap when the joint is fully bent. If this happens, the lame should be removed and the hole filled and replaced at a better location. Remember that it is sometimes better to craft a new lame rather than try to fix an incorrect one several times. When a new

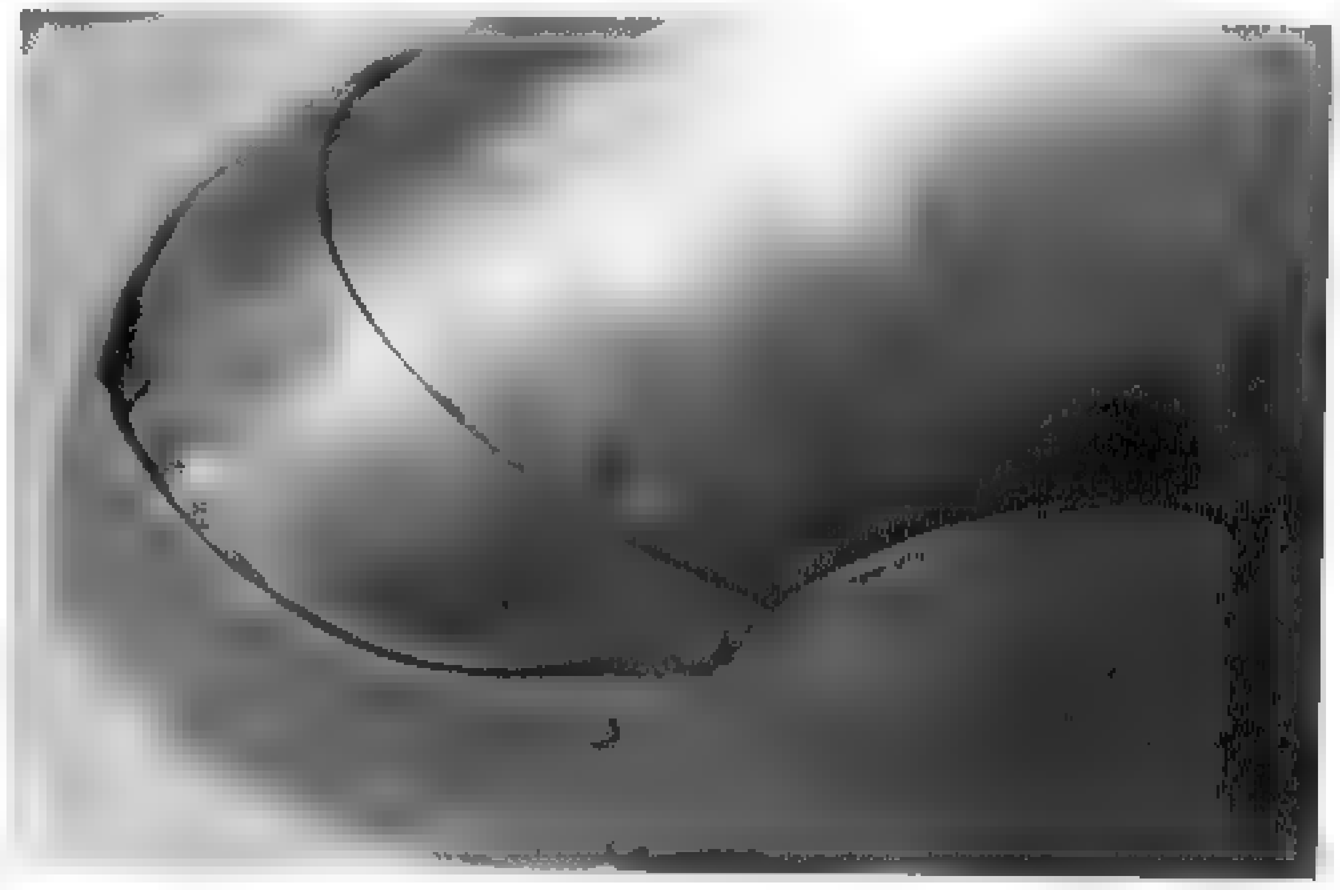


Figure 20.14. A finished legharness articulation by the author. Note that the slightly domed lame at full extension has very little space between the poleyn or the cuisse. This snug fit is critical to the joint's function.

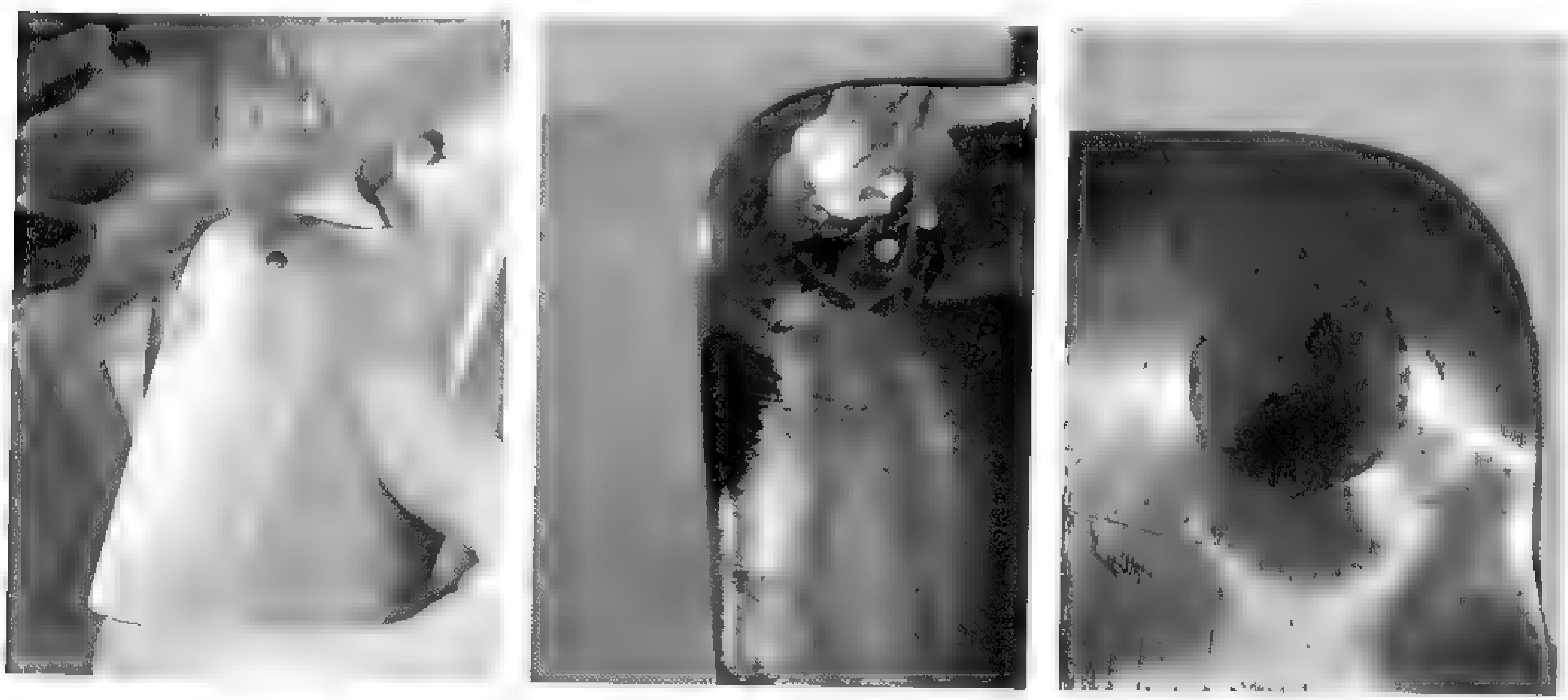


Figure 20.15. Occasionally the armourer will punch a hole in an incorrect location. Rather than throwing away the lame, the hole can be filled by aggressively pushing metal into it using a round ended hammer and ball stake.

pattern is being worked out, try to articulate a sample before cutting and shaping all four; otherwise you may discover that the pattern is wrong enough to require new lames, thus wasting the time and materials spent on the first attempt.

Gaps between the shell, lames, and limb defenses should be no more than 1/8 inch, less if possible. Sometimes a larger gap cannot be avoided, but every effort should be made to insure that the gap is as small as possible, both to help the metal retain its original shape under the stress of a blow and to improve the nearly seamless appearance of a medieval joint.

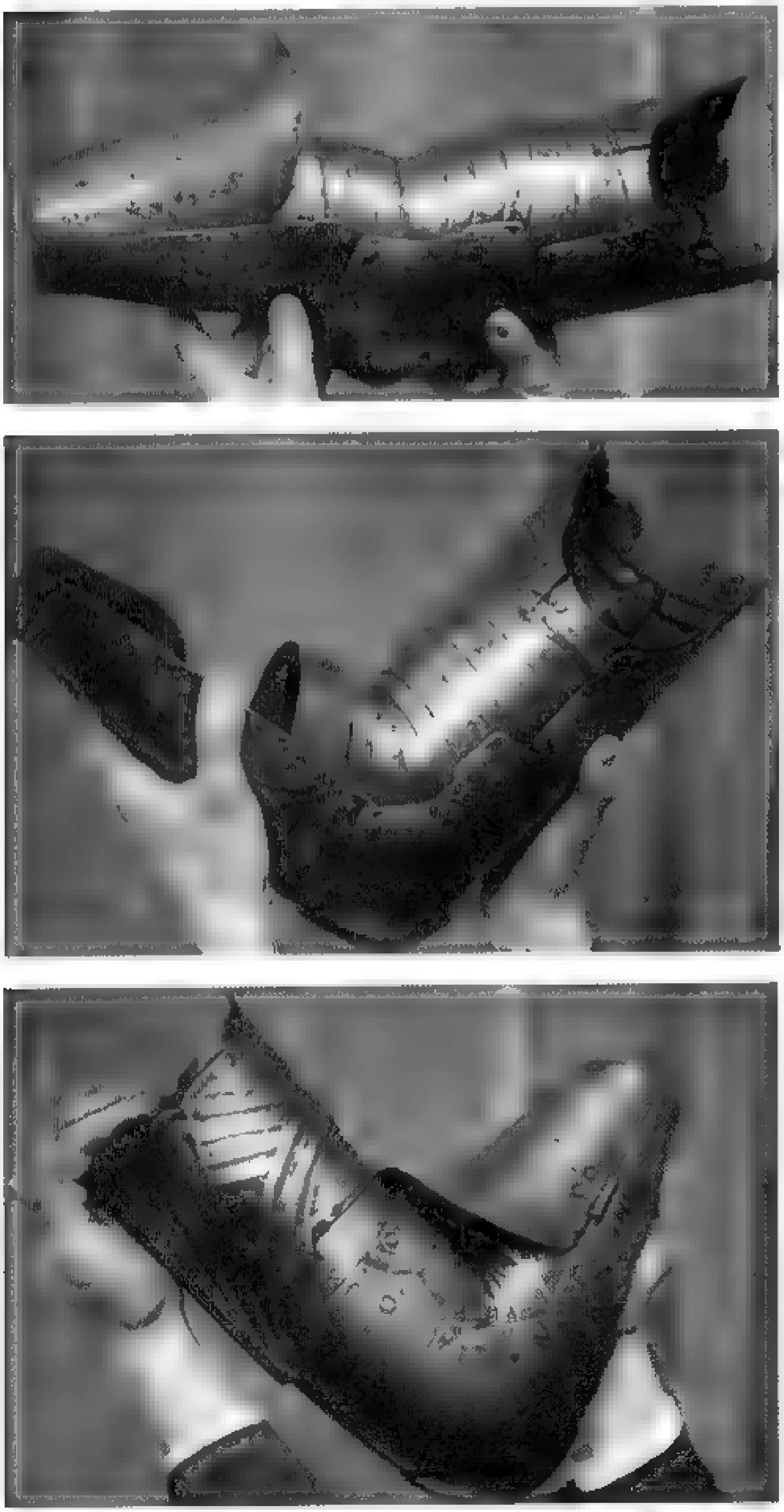


Figure 20 16 Compression articulations in a 16th century arm harness

Articulations may develop gaps over time, a condition that is often caused by the wearing away of the metal around the rivet allowing for enough play in the joint to cause the lame to pop out from under the shell and remain fixed in place. The only solution for this is to fill the old hole with weld, add a patch with a newer, original diameter hole, or stretch the material on the inner edge of the lame to extend the overlap between the lame and the shell.

COMPRESSION ARTICULATIONS

When a joint needs to contract with movement, as at the wrist, foot, or waist, there are two ways to engineer it. The first is with a pliable binding that affixes one plate to another, the floating articulation discussed above. While this method does provide superior movement, it is high maintenance and does not provide the strength of a plate-to-plate attachment.

To accomplish the joint without a binding material, a stepped articulation is used. In such a joint, the plates are at their maximum extension and cover the maximum amount of surface area. When the joint bends, the lames collapse under one another, neatly compressing together to reduce the space required and allowing the joint to move.

Unlike a shell articulation, movement in a stepped joint is accomplished through the use of many small lames, each affixed with four rivets, two to each neighboring plate. In order to keep the plates from moving beyond their allowable range of motion, a binding strap is often run down the joint's center, two large-headed rivets holding each plate in place.

Compression articulations were first used in the last decades of the 14th century as armourers began to wrestle with the problems associated with moving rigid plates in relation to one another. Starting in the 1380s, faulds, sabatons, and spaulders may well have been joined with compression articulations rather than floating.

The technique seems to have been in wide use by 1420 and on through the 16th century.

Unfortunately, very few early examples of such articulations survive. The sabaton portion of a nearly complete legharness preserved at Chartres Cathedral (fig. 20.17b) is one notable exception. In this example, two rows of rivets extend down the line of narrow lames. The tomb of the Black Prince at Canterbury shows another similar construction (fig. 20.18).

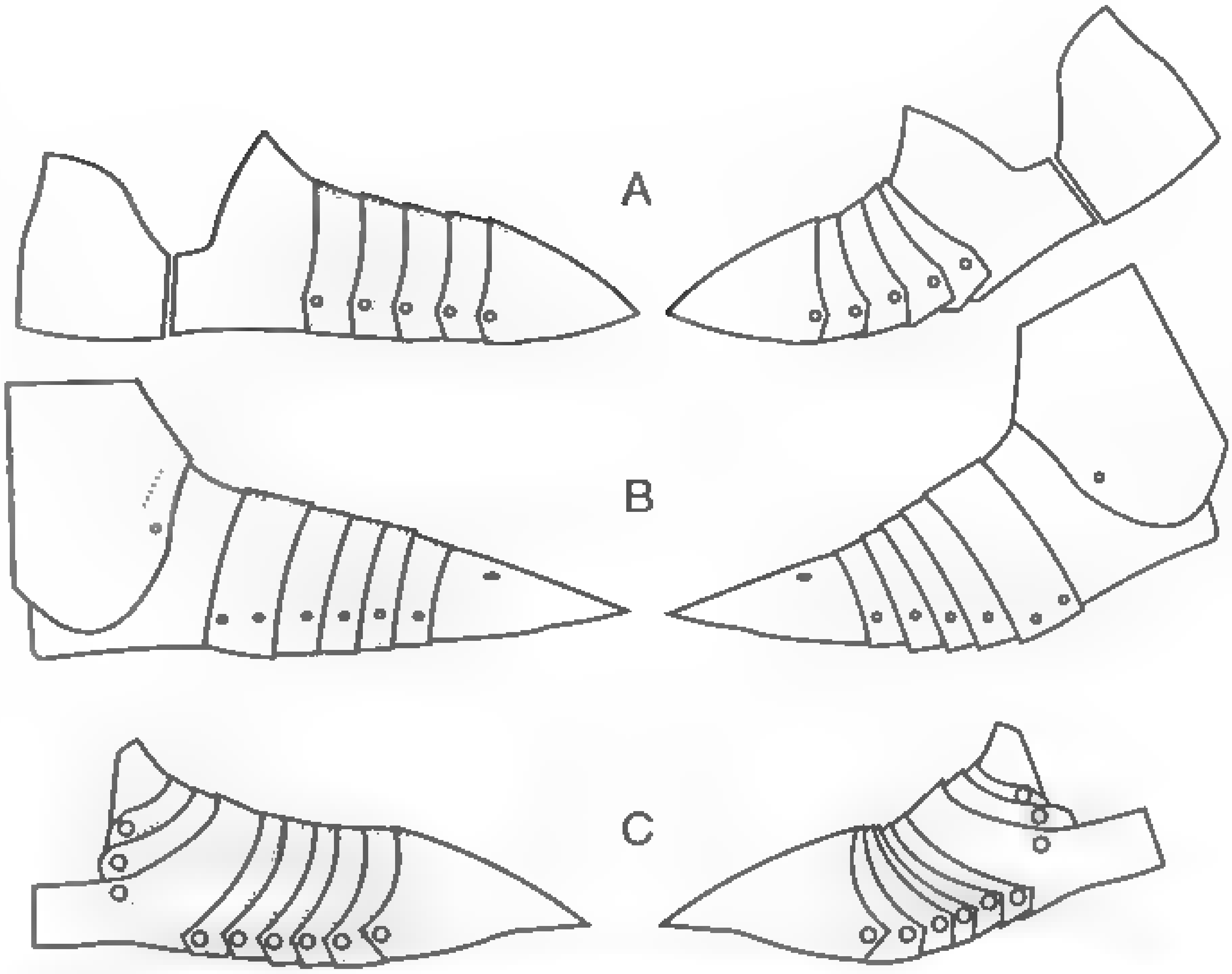


Figure 20.17 Examples of step articulations for the sabaton, showing three examples. (A) is based on the Warwick harness (a Milanese harness dating from the 1450s), (B) is a 14th century version from the child's armour at Chartres, and (C) shows a German variant from the late 15th century, demonstrating consistent use of a successful solution.

The sabaton was probably the first place where such engineering was used. Early sabaton defenses seem to have been plates layered over the top of the foot, probably bound in place by floating articulations on internal leathers (figs. 20.3a–b). By 1400 some sabaton defenses were extended to the base of the foot, where floating articulations prove less satisfactory because the stress on the foot causes the leathers to stretch and pull the plates out of place.

Early step articulations for the sabaton appear to have been simply extended versions of the floating technique. Rivets were attached at the base of each plate nearest to the floor, one to each side, binding each plate to one other (fig. 20.17b).

By at least 1400, some armourers were adding a pivot lame between the greave and the sabaton (fig. 20.20). All the other lames fanned out from this pivot plate, yielding surprising mobility without making the articulation appreciably more difficult.

Similar construction techniques were probably used in shoulder defenses toward the very end of the 14th century (the earliest surviving Milanese pauldrons are done in this manner), but unfortunately there is no solid

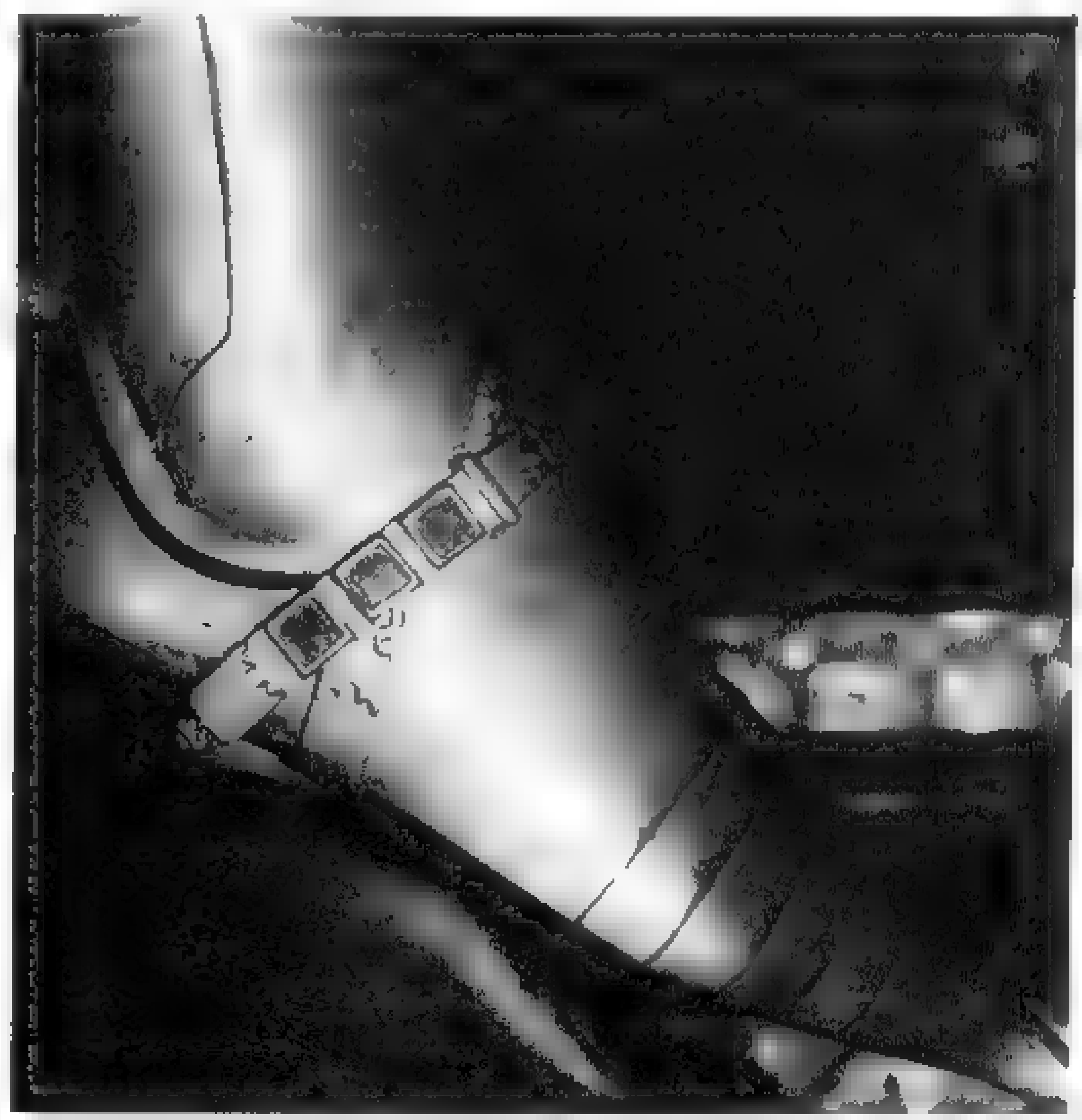


Figure 20.18 Sabaton from the tomb of the Black Prince, Canterbury Cathedral, c. 1376. Simple stepped articulations fan outward from the toe toward the ankle

record to show when or how often the technique was used over the earlier floating joint.

Early on, this simple step joinery for the pauldron was enhanced with the innovation of sliding rivets. Sliding rivets are made by cutting slots into the inside plate of an articulation, the rivet binding the two plates together with the assistance of a washer or broadly piened head on the inside. Sliding rivet slots on a shoulder harness are typically from 3/8 to 3/4 inch long and are often bound with floating leather straps on the front. During the 16th century some examples used sliding rivets on both sides of the compression joint, though this is less common than the sliding/floating combination mentioned above.

The earliest example of a sliding rivet comes not from a pauldron but surprisingly from the #13 arm harness at Churburg (fig. 20.19). In the manner common to Milanese armours of the following century, the Churburg vambrace is actually cut with slots to allow side-to-side movement through the use of sliding rivets. Given this single isolated example—dated from 1360–1380—it is an intriguing question as to when the sliding rivet actually came into use, though it was almost certainly restricted to vambraces and pauldrons since there is little need in the legharness or hourglass gauntlets.

There are effigies and brasses that seem to show some use of stepped articulations on hooplike defenses for the hand during the third quarter of the 14th century, as shown on the gisant of Sir Hugh Dispenser, c. 1349. Into the 15th century some multiple-piece cuirasses continued to be articulated on internal leathers. Italian export and German armours most

Figure 20.19 A rare interior view of the Churburg #13 arm harness showing the Italian-style vambrace pivot. Note that this construction remained in use by the Milanese armourers throughout the 14th century; the range of motion for the elbow is provided by the other two lames alone. (Photo courtesy of Count Von Trapp.)

commonly made use of the technique, while the better Milanese armourers seem to have favored step articulations for the construction of the backplate and faulds.

German gauntlets during the 15th century used compression rivets to assemble the many-plated, elongated gauntlets distinctive of their style. Like the sabaton, a pivot plate was seated at the wrist, the lames riveted in a radiating pattern outward toward their eventual anchoring on the long wrist piece and to the first of the metacarpal defenses. These plates were also formed in multiple narrow strips rather than from a single metacarpal plate, as had been the standard previously on the dominant hourglass gauntlet. The international style of the 16th century saw wholesale adoption of the multiple piece technique for the gauntlet.

Figure 20.20. A 16th century gauntlet assembled using step articulation techniques. Note the presence of a pivot plate (the one with two dome-headed rivets) This construction style can be traced directly back to the German armourers, who formed their gauntlets using precisely the same technique. In rare instances the pivoting rivets were also sliding rivets, adding a bit of side to side motion, though this seems to have been a minority application. On this gauntlet the fingers are affixed with two rivets to leather strips, and a central leather band ties each lame of the metacarpal and cuff together. (Photo by the author, Park Lane Arms Faire, 1987.)

Step Articulation Theory

Step articulations are remarkably easy—not nearly as challenging as their complex appearance suggests, and far easier than a good shell articulation.

For 14th century armour, the sabaton is the only place where step articulations are certainly appropriate, though they become more common as the 15th century progresses.

The first time a pattern is attempted using step joinery, the bottom plate should be done first. If this is a sabaton, for example, most 14th century solutions would begin with the toe, working back toward the ankle. Although each plate is very similar, the length is different in each case, so the pattern should be made one plate at a time and the pieces carefully marked for future reference. Each plate that rides atop another is slightly larger in width than the last, and care must be taken to insure that the rivet points line up and that the edge of the articulation forms a smooth arc. The easiest way to do this is to leave extra metal at the edge and trim when the articulation itself is complete.

Working from the bottom plate (in this case the toe—fig. 20.21a), form another plate that just fits over it and leaves extra at the edges for trimming (fig. 20.21b). The plate should overlap by something between 1/4 and 1/2

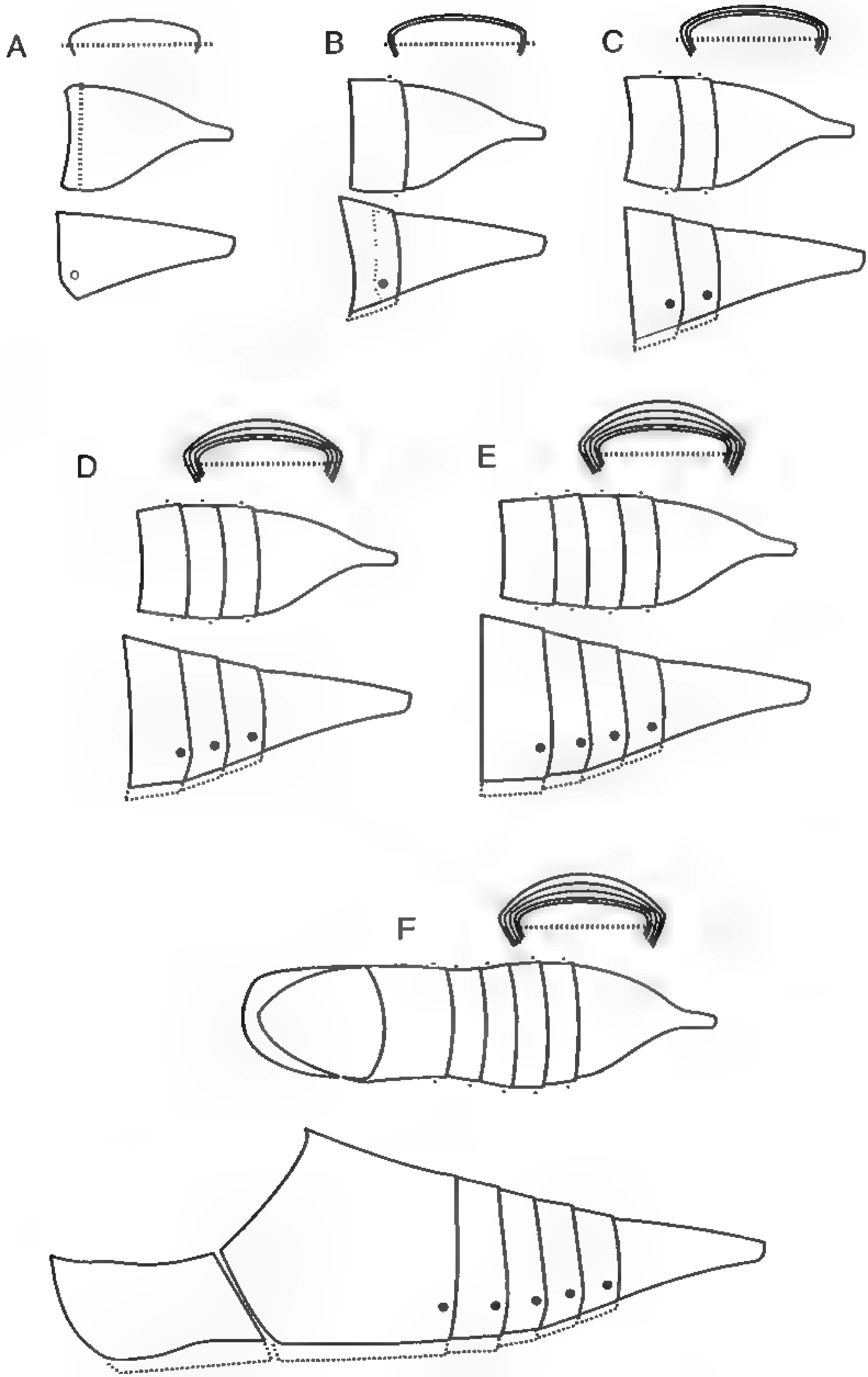


Figure 20 21. Articulating a sabaton using stepped articulation.

Figure 20.22 A 14th century child's sabaton from Chartres

inch, depending on the piece. Each plate will overlap the other by something less than half its width. Each lame should fit snugly with the one below it with no gapping.

Place the pivot holes such that a single rod could run through both holes, exactly as is necessary for shell articulations (fig. 20.17a). The plate is bolted into place and the next one made (fig. 20.21c). When all of the plates are in place, the desired line for the edge should be marked and each trimmed and filed (fig. 20.21e).

As long as these techniques are followed and the rivets set without excessive force, the step joint will compress easily.

ENDNOTES

1 Pictured in Stephen Bull's *An Historical Guide to Arms and Armour*, 1991, p. 56
2 Also gauntlets, though no examples survive outside of funerary brasses
3 This could explain the reason why construction rivets are often missing from effigies and funerary brasses. The rivet would be invisible on the exterior and so would not be reproduced
4 Blair, Claude, *European Armour*, p. 63, see also the Stapleton effigy, Figure 20.3
5 The effigy of the Black Prince shows a well-evolved shell articulation for the knee featuring the characteristic single lame above and below the poleyn. The effigy itself can be dated to 1376, though the author suspects the leg defense was in use during the prince's lifetime, c. 1356–1376.

Chapter 21

Latches, Catches, Hinges, and Buckles

Once formed and finished, armoured elements not riveted in place may require additional hardware in the form of latches, catches, hinges, or buckles to be functional. Some armourers have termed this fine work "locksmithing" because it usually involves a great deal of detail work as the pieces are roughly cut and filed to shape. Like most specialty techniques, many medieval armouries probably employed specialists to make these intricate pieces, but because of their small volume of production modern armourers must usually craft these components themselves.

The appropriate solution to the problem depends largely on the stylistic family to which the piece belongs: close attention should be paid to the medieval originals, as most of these elements remain. Too often, good reproduction work is marred by details in the locksmithing parts that are glaringly modern.

LATCHES AND CATCHES

In the 14^{th} century there were surprisingly few mechanical latches, except for the helmet visor attachments on bascinets. As the Milanese and German armourers advanced the armourer's skill with plate iron, however, a multitude of catches were devised to hold

Opposite page Figure 21.1 A particularly nice latch on a reproduction piece by Robert MacPherson

visors, cheek plates, and reinforces and to effect closure on vambraces and greaves.

Post

Most plates were secured during the 14th century with buckle and strap arrangements, although vambraces and greaves were also sometimes closed using a simple post (fig. 21.2a). While this technique was used in the 14th century only for vambraces and greaves, it was sturdy enough to see use even on helmet visors in the 15th and 16th centuries.

To make a post latch, two plates that will open and close are first fit with a spring tension between them, as is frequently done with vambraces and greaves. This springy fit is the key to making the post work, since the spring is actually the plate itself.

A hole is first punched in the "under" plate. This hole should be the same diameter of the rivet that will serve as the post, usually 3/16 or 1/4 inch. A mark is made on the outer plate and a slightly larger hole punched, usually less than 1/4 inch for a 3/16 inch post.

The post itself is then gently set into the first hole and the top rounded with a file. If set properly, the vambrace or greave will act as a spring that keeps the post secured in the hole. To open, simply pull the plates apart with some tension and the post will slip out.

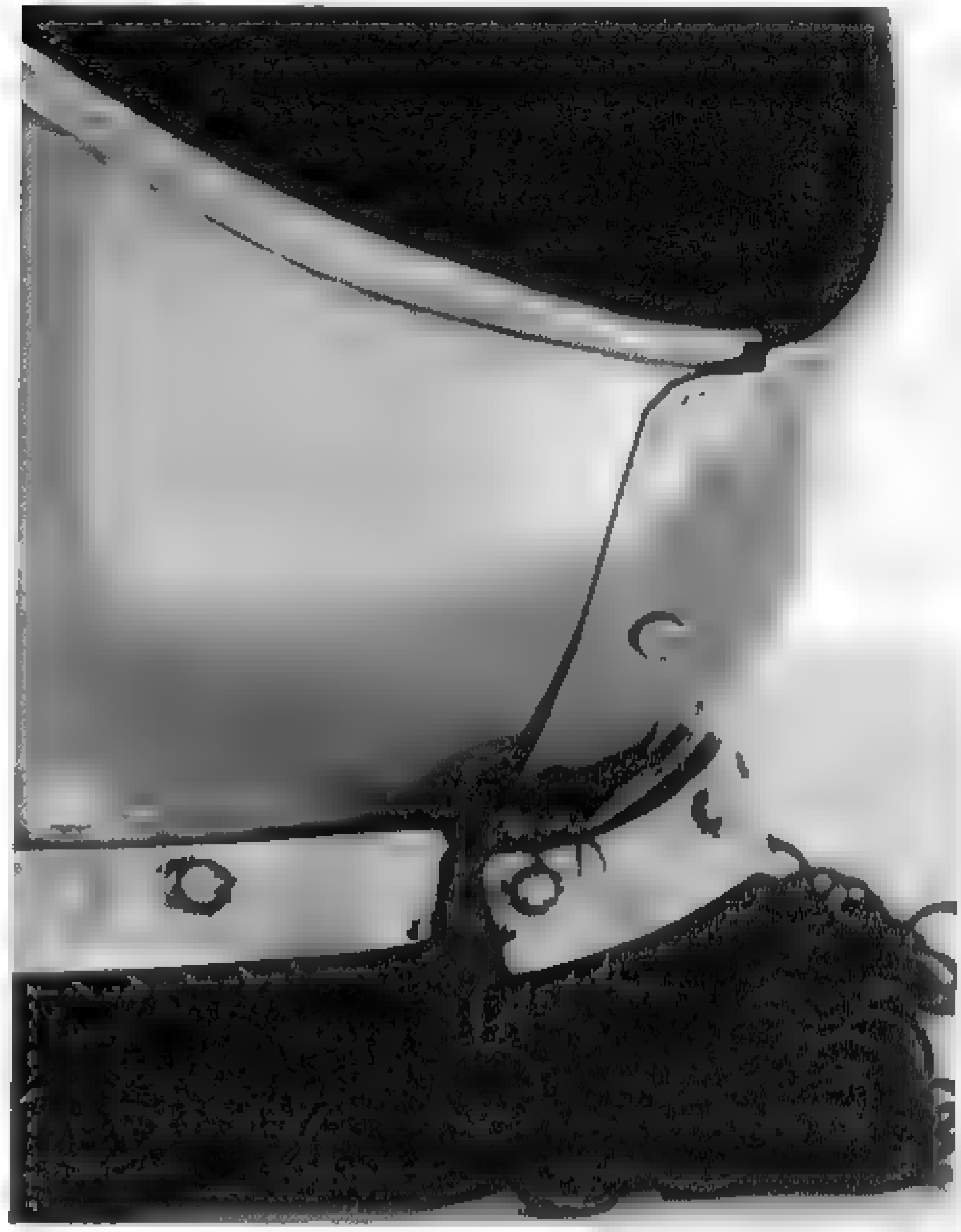


Figure 21.3 The post-and-hole closure technique shown on this armet a rondel by Aaron Toman and Wade Allen was a common alternative to a strap and buckle closure from the end of the 14th century onward. In this case the plates themselves act as springs to hold the post in place, while in later versions a separate spring was sometimes incorporated into the design (figs. 21.2b–c)

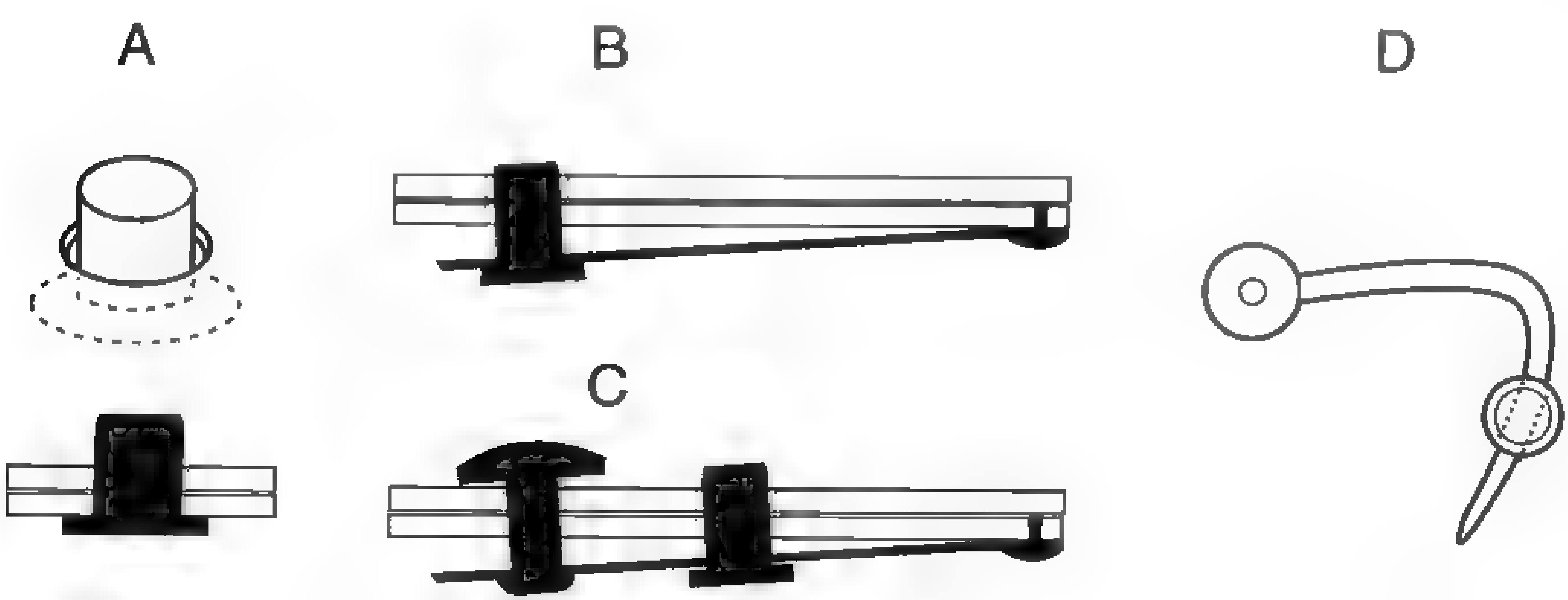
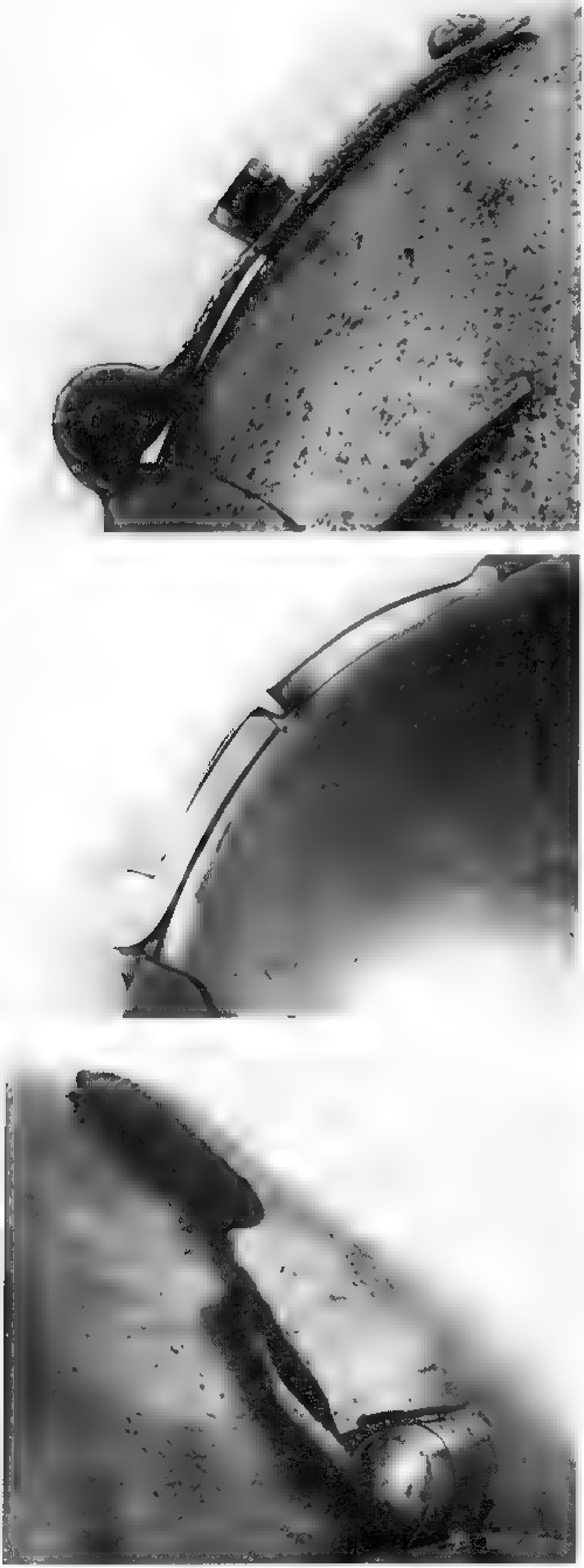


Figure 21.2 Various types of latches



Spring and Post

During the 15th century, the simple post closure was enhanced by the inclusion of a separate variation that added a very thin, springy plate to the closure, reducing the reliance on the plates themselves (fig. 21.2b). This probably came about because in a regular post closure, a blow on the inner plate or deformation in the outer plate can cause the closure to release. When crafting pieces for combat, the armourer and combatant should be aware of this weakness and devise techniques to insure that critical closures (as on the helmet) do not come unfastened during the action.

Spring with Push Lever

The next evolution in the spring and post closure technique seems to have been developed at the end of the 15th century. Both the spring and post closures tend to be difficult to open, so in response a large push-post was sometimes added, often decorated with a rosette pattern (fig. 21.2c). Using this variation, more leverage can be brought to bear on a tight spring, although the push-post can be struck directly in combat, which will open it.

Post and Hook

Another innovation at the end of the 15th century was the post and hook, a defense that dispensed with the spring requirement and instead used a scythe-shaped hook to secure the post in place (fig. 21.2d). The post was carefully pierced to accommodate the hook

Figure 21.4. Sample bascinet center-mount closures of the middle to late 14th century. Although not all visors were interchangeable, as some hinges did not feature a mechanism for removal, the majority of surviving examples do. Shown here are three examples, two courtesy of the Trustees of the Royal Armouries (top and middle) and one from the Valeria Museum in Sitten, Switzerland, (shown fully in fig. 30.31). Two main variations are shown. The turnkey version, top, has two pins. One is secured to the bascinet passing through a guide hole on the latch. The lower pin is a turning latch that pivots on the bascinet skull, fitting through an oblong opening on the visor's hinge. When turned, the visor is secured in place. The second version is a "paddle" mechanism. The bascinet hinge passes over two staples (see also fig. 21.1), and the paddle pivots to turn and hold the hinge in place. (Top and middle photos © Board of Trustees of the Royal Armouries, detail of IV. 467; detail of IV 6.)

(be careful when piening the post or the hole can crush easily).

The characteristic scythe shape on the hook was an important component of the defense, for it is virtually the only shape that will hold and provide the needed leverage. As effective as the technique is, it is only truly appropriate on pieces from the late 15th and 16th centuries.

BASCINET VISOR ATTACHMENT TECHNIQUES

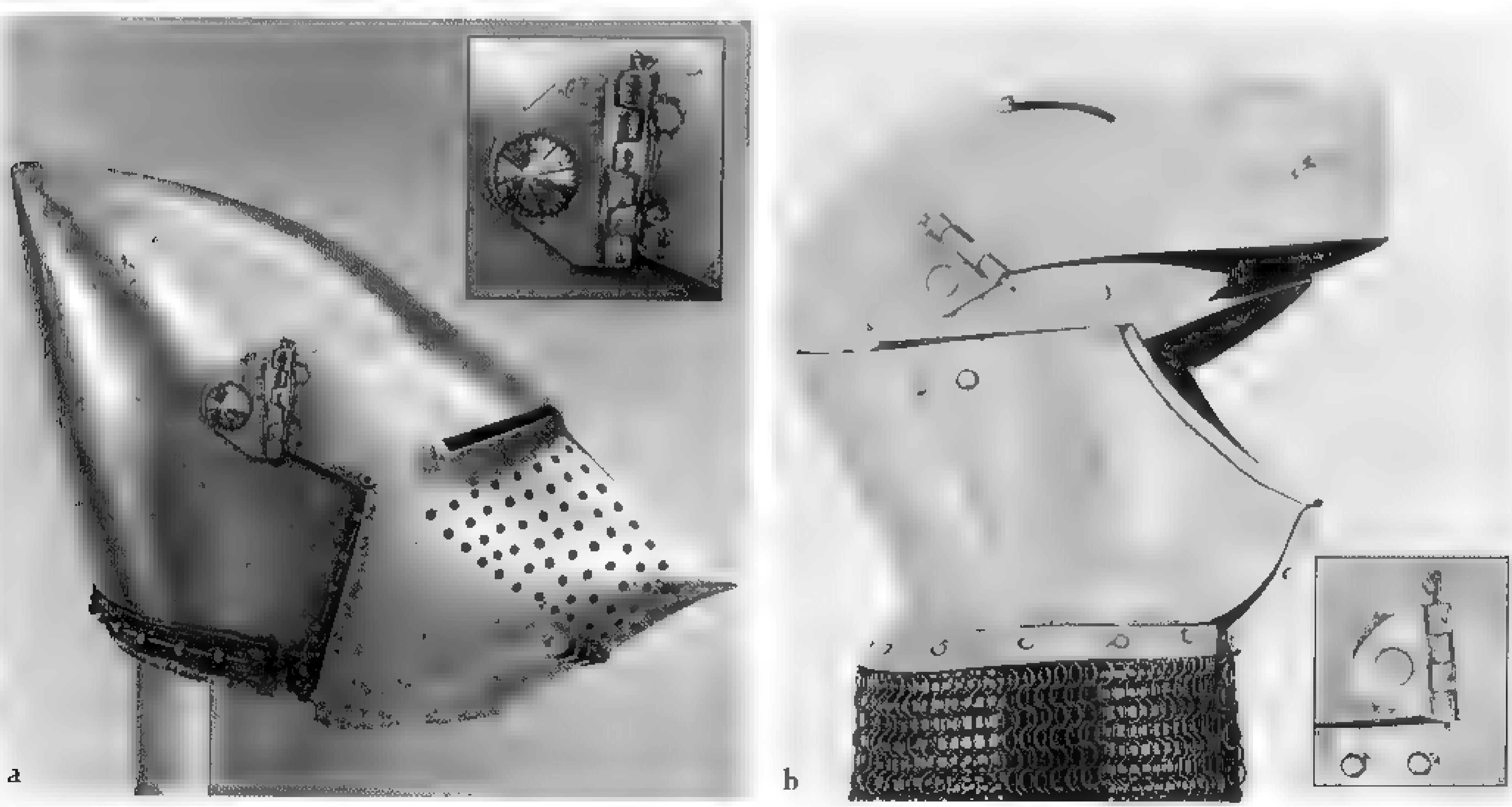
The one place where 14th century armourers provided a great deal of innovation in locksmithing techniques was in the evolution of the visor attachment for the bascinet. Over the course of only 50 years, numerous closure techniques securing the visor to the helmet came in and out of fashion. Eventually, the pervasive side-mount technique was carried over into the helmets of the 15th century, largely unchanged in form.

The first bascinets featured different forms of center-mount hinges (figs. 21.1, 21.4). Because of the hinge's relatively vulnerable placement, most were large. It is likely that there was a requirement for the bascinet visor to be removed quickly in combat, as the early latches in particular seem to favor arrangements that could be removed with a gauntleted hand. The making of a center-mount latch is demonstrated in Chapter 30.

By the third quarter of the century, the center-mount visor had given way to a side-mounting technique shown in Figure 21.5. The bascinet visor was now hinged on two sides, providing redundancy in the closure, but it could now be raised high enough that a quick removal was probably not as pressing in combat, though the capability seems to have been preserved all the way through the 15th century.

HINGES

With the development of fully enclosing vambraces, greaves, rerebraces, and cuirasses, the armourer was faced with a need to manufacture hinges. While some of these—including the bascinet hinge shown in Figure 21.5 and the vambrace shown in Figure 21.6a—were integral with the plate itself, the



a b

Figure 21.5 A combination of the earlier hinge technique was devised during the 14th century for bascinet visors (A) remaining in use throughout the 15th century in great bascinets and armets a rondel shown here in this fine example by Wade Allen and Aaron Toman (B) (Bascinet (A) courtesy of the Metropolitan Museum of Art, NY, Rogers Fund, 1904, 04 3 325)

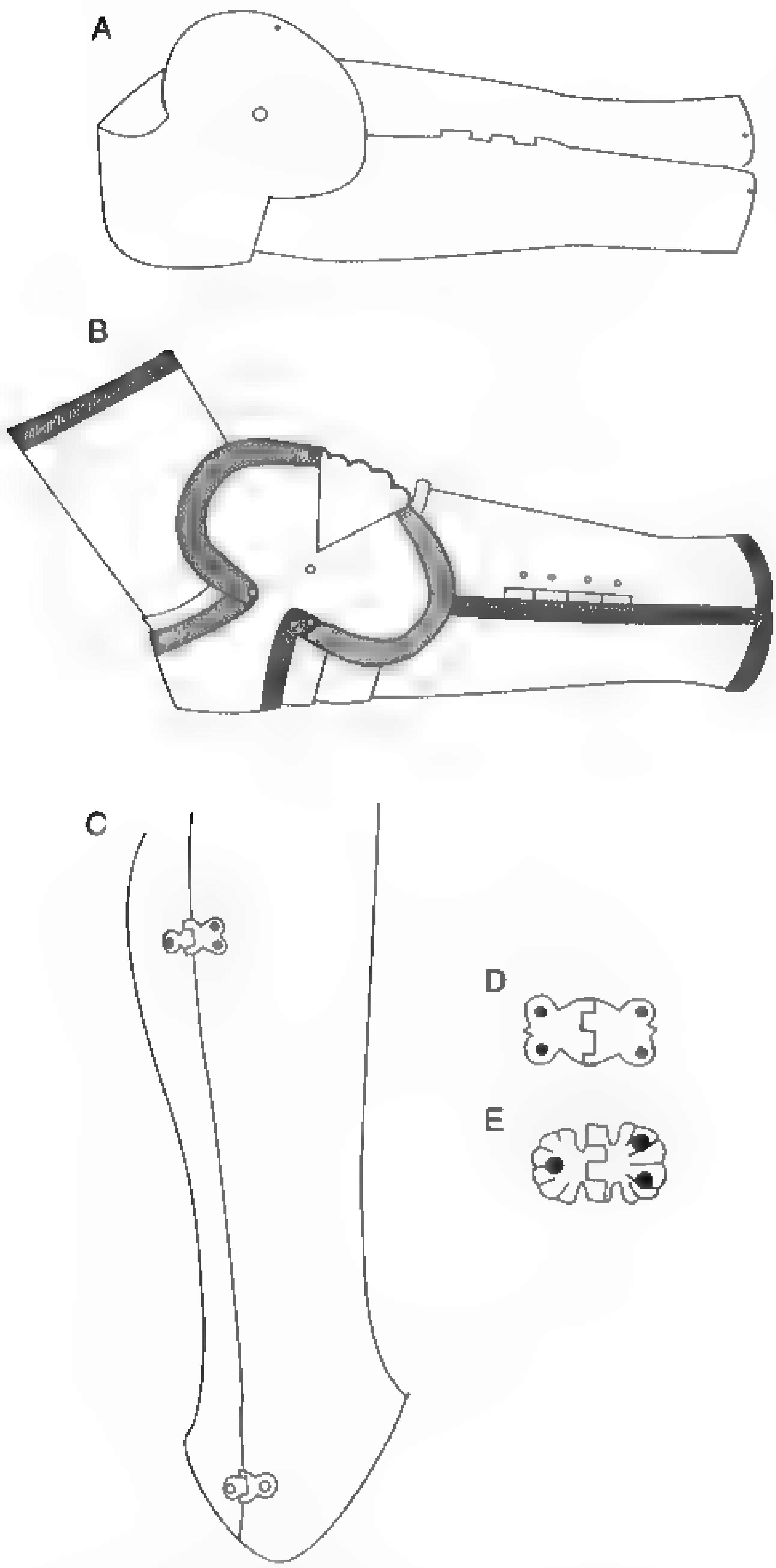


Figure 21 6. Hinges from the 14th and 15th centuries. Early defenses were sometimes hinged using the plate itself, as in this vambrace for a child in Chartres Cathedral, c. 1370–1390 (A) The hinge on Churburg #13 (B) uses a separate hinge riveted to the interior of the vambrace with eight rivets and the cut-out necessary to accommodate this construction. (C) is a Milanese greave from 1450 showing hinges placed on the outside. Most Milanese greaves were fitted with interior hinges, while German armourers seem to have favored placing the hinges on the outside. The two single hinges are from 15th century defenses. (D) is from a Milanese cuirass and (E) from a Gothic greave in the Wallace Collection

vast majority were made from thin iron or latten material and riveted in place.

The hinge is basically made from a single thin sheet folded in half, cut and fit with similar plate, and riveted into place. Normally, hinges were made from iron rather than latten or copper alloy, although starting with some German Gothic armour of the late 15th century, brass was used with increasing regularity. Some hinges were placed on the inside, and in this case they were rather roughly finished and riveted to the back of each plate, the tubular section protruding to the surface. The only difficulty with this technique is that the plates must be cut out around the hinge (32.18), and riveting them in place can prove quite a challenge.

An easier technique—and one that seems far more common—is to create a decorative hinge and rivet it to the outside of each plate with a dome-headed rivet. The advantage to this is that the plates do not have to be cut out, though shaping the hinge in a pleasing manner can take just as long. On some Milanese vambraces of the 15th century the armourers used one interior and one exterior hinge for reasons that remain obscure.

Modern armourers often attempt to modify a commercial hinge, but this practice should be avoided unless the hinge is hidden and the armour is a munitions project, as hinges are simple to make. The commercial version detracts significantly from the piece's medieval tone.

Making Hinges

Hinges are really quite simple to make. Choose sheet steel of 18 or 20 gauge thickness; thicker material will impair the function of the hinge for everything but visor mounts, and thinner stock does not have sufficient mass.

I like to use spray adhesive to attach a paper guide to each piece, though with practice this can be omitted (fig. 21.7a).

Each hinge will require two pieces, one for each side (fig. 21.7b). Each will be folded in half around a nail, filed to shape, and assembled.

First, cut the pieces on the shear, being careful not to cause twisting. Allow extra

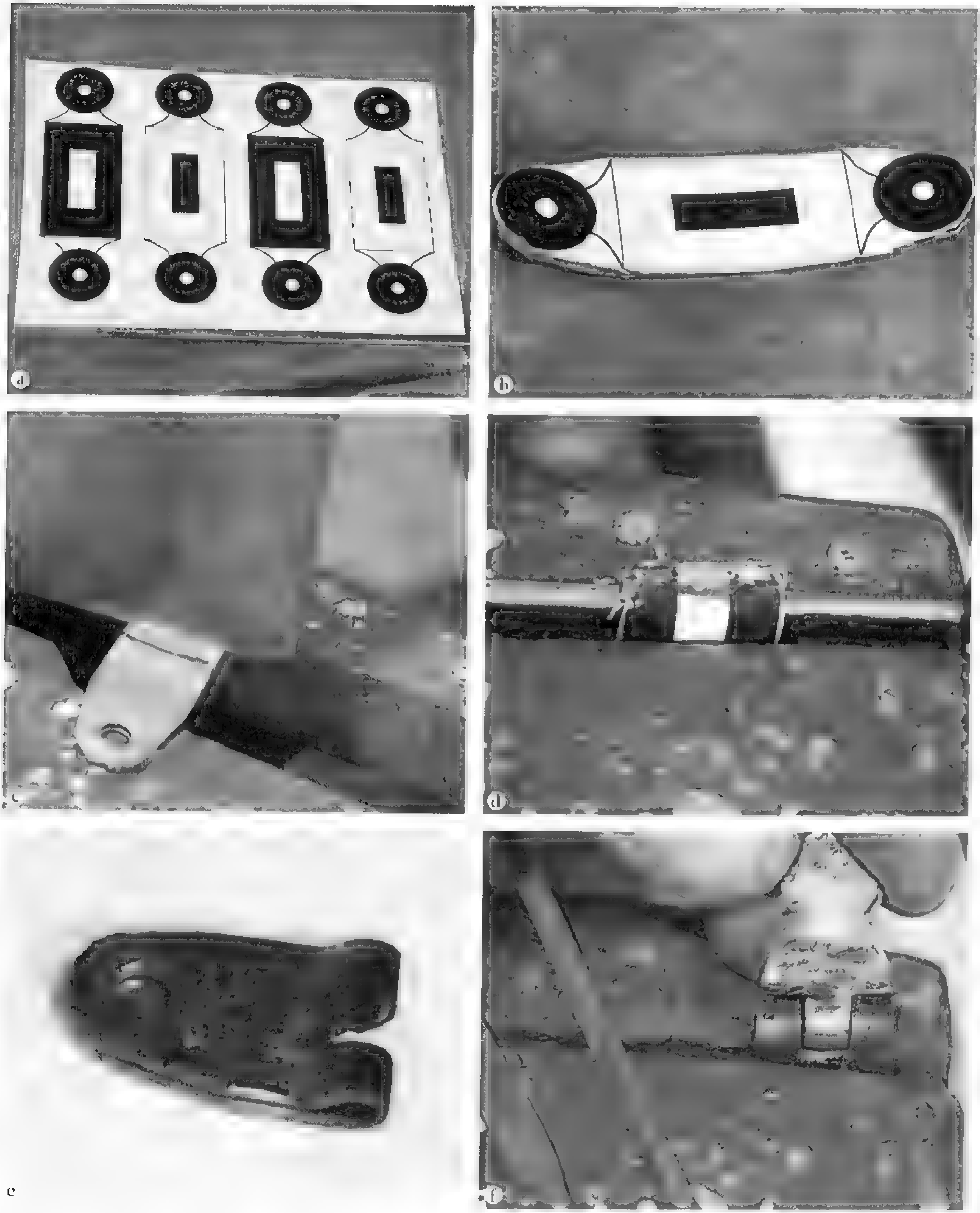


Figure 21 7 Making a hinge

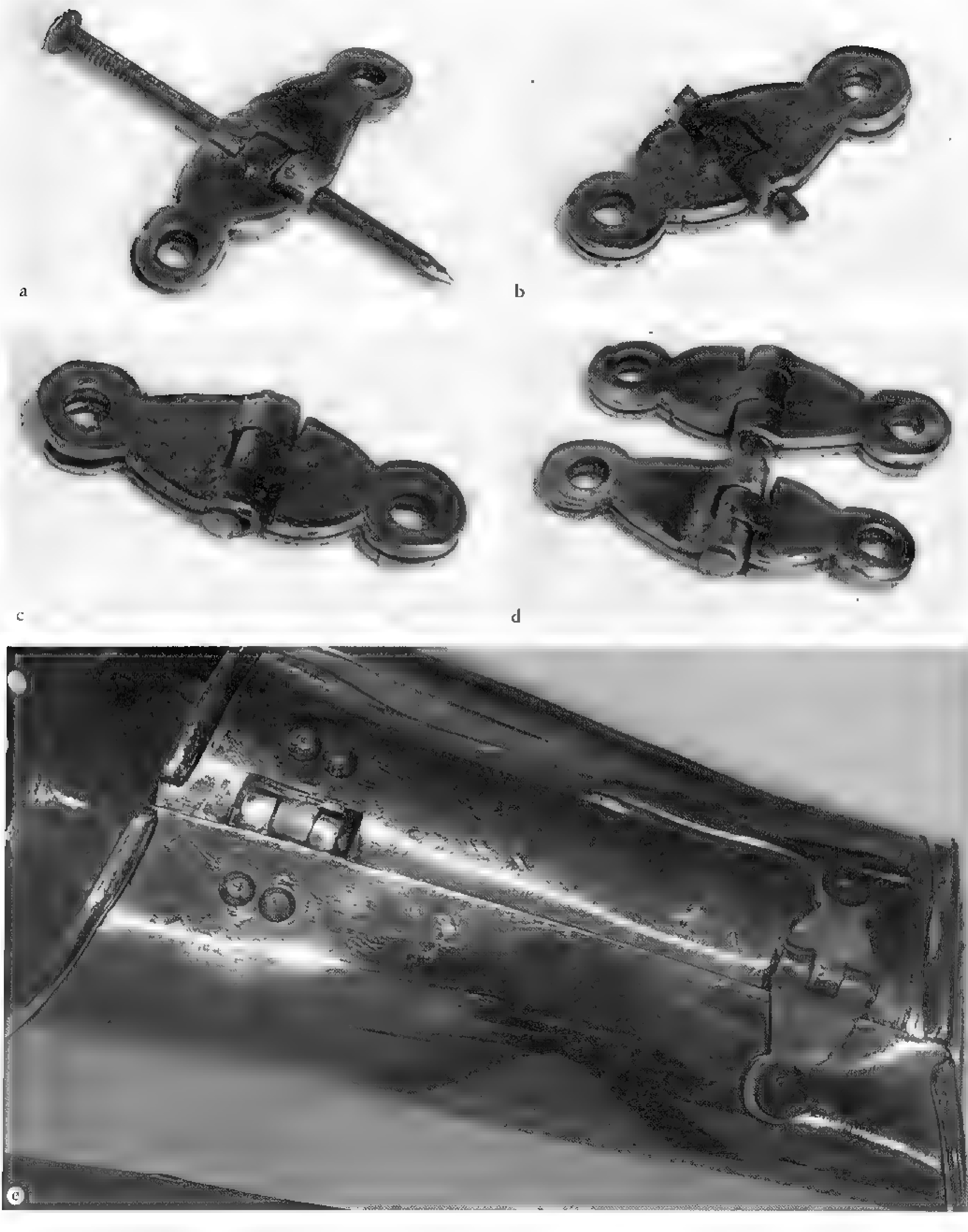


Figure 21 8. Making a hinge (continued)

metal, since it can easily be sanded or filed away after the bend is made.

Using a bench vice without teeth and a long, dull chisel, gently tap the hinge down into the vice (fig. 21.7c). For small hinges the jaws should be roughly 1/2 inch apart. When the piece has been pressed into the vice with the chisel, remove it and insert a nail, turning the piece upside down and compressing it between the jaws once more (fig. 21.7d). The nail will keep the rounded shape necessary.

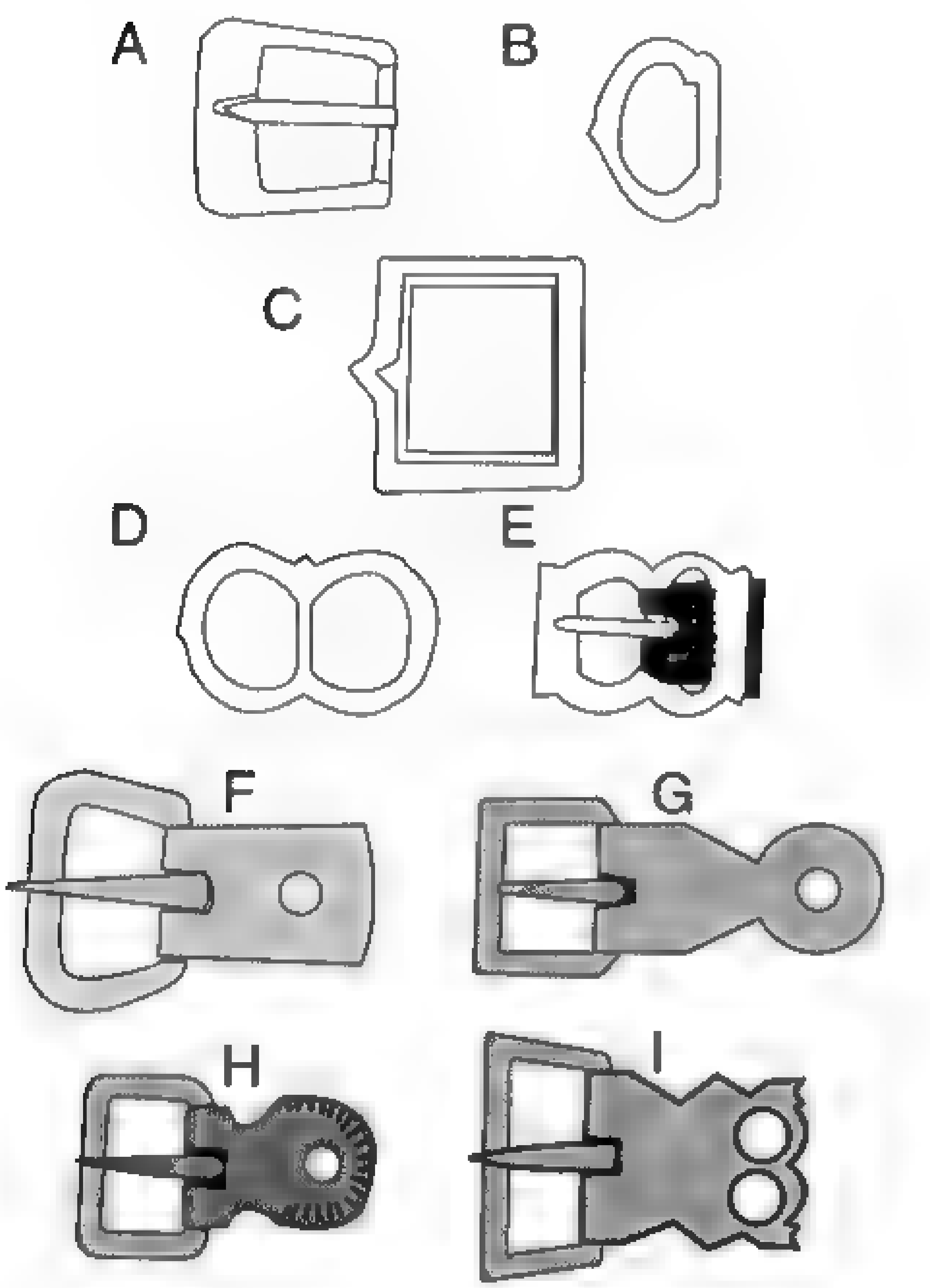


Figure 21.9. Various buckles appropriate for harness from the 14th and 15th centuries. (A) is a typical square variant common after the middle 14th century. (B) is a pointed style that seems to have been limited to use prior to the mid-15th century. (C) is another square variant, found in London. (D–E) show figure 8 or double-loop buckles that were popular from 1350 onward, although the shape changed with fashion. All of these buckles were cast from a copper alloy, although we don't know to what extent cast buckles were used prior to the 15th century. Figures F–I are all iron buckles, mostly flat in cross-section, affixed to armoured elements from 1400–1480. One popular variant shown in each of these is the tendency to use a 18–20 gauge plate rather than leather to affix the buckle to the plate for durability, decoration, and ease of maintenance.

Now the nail can be removed and the same procedure followed with the other piece. Each is now filed to shape (figs. 21.7e–f), a process that can be sped along by punching conservatively before the bending process once the armourer is experienced with the overall procedure.

This step must be most done carefully to maintain a close fit. A nail is now inserted through both pieces and clipped (figs. 21.8a, 21.8b). Once the holes are drilled, the hinge can be test-fit, where it will probably be found that some bending is necessary to insure a proper fit. Buckles that are destined for the outside of a plate should be shaped; use the original references to select the appropriate forms. Before assembly the hinges should be buffed. Sometimes the back can be painted or the whole hinge tinned in order to reduce the risk of rust

BUCKLES

Given the evidence from archeological finds in the last two decades, the medieval citizen seems to have had quite a taste for buckles and strap ends in a dizzying variety of shapes and materials.

With respect to armour, a more limited subset of the same stylistic families can be found, although there are few examples remaining affixed to armoured elements prior to the 15th century. Some armourers likely purchased appropriate buckles from other craftsmen—cast products of latten or other copper alloy, sometimes washed in gold or silver, tinned, painted, or even enameled. When the armourer made buckles, it is unlikely that he cast his pieces but more probably manufactured them from flat or barstock, forge-welding the hoops.

Most buckles that remain attached to armour are of this latter group, because these buckles were affixed using thin sheets of plate riveted to the harness itself (figs. 21.9f–i). Buckles attached with straps are more varied in shape (figs. 21.9a–e).

The modern armourer has similar options. Several vendors now sell buckles appropriate for

use with armoured strapping, and the flat variety can also be easily made with minimal tools.

To make a simple square buckle, take 3/32 inch welding rod and form it quickly into a square (fig. 21.10; a piece of 1/2 inch square barstock will he helpful for this). Weld the open end and flatten the whole piece with a hammer (smash only the three outer sides), adding chisel designs if appropriate (fig. 21.10). The tongue can be easily cut from a piece of 18–20 gauge flat stock, sanded and gently curled around the rod. That's it!

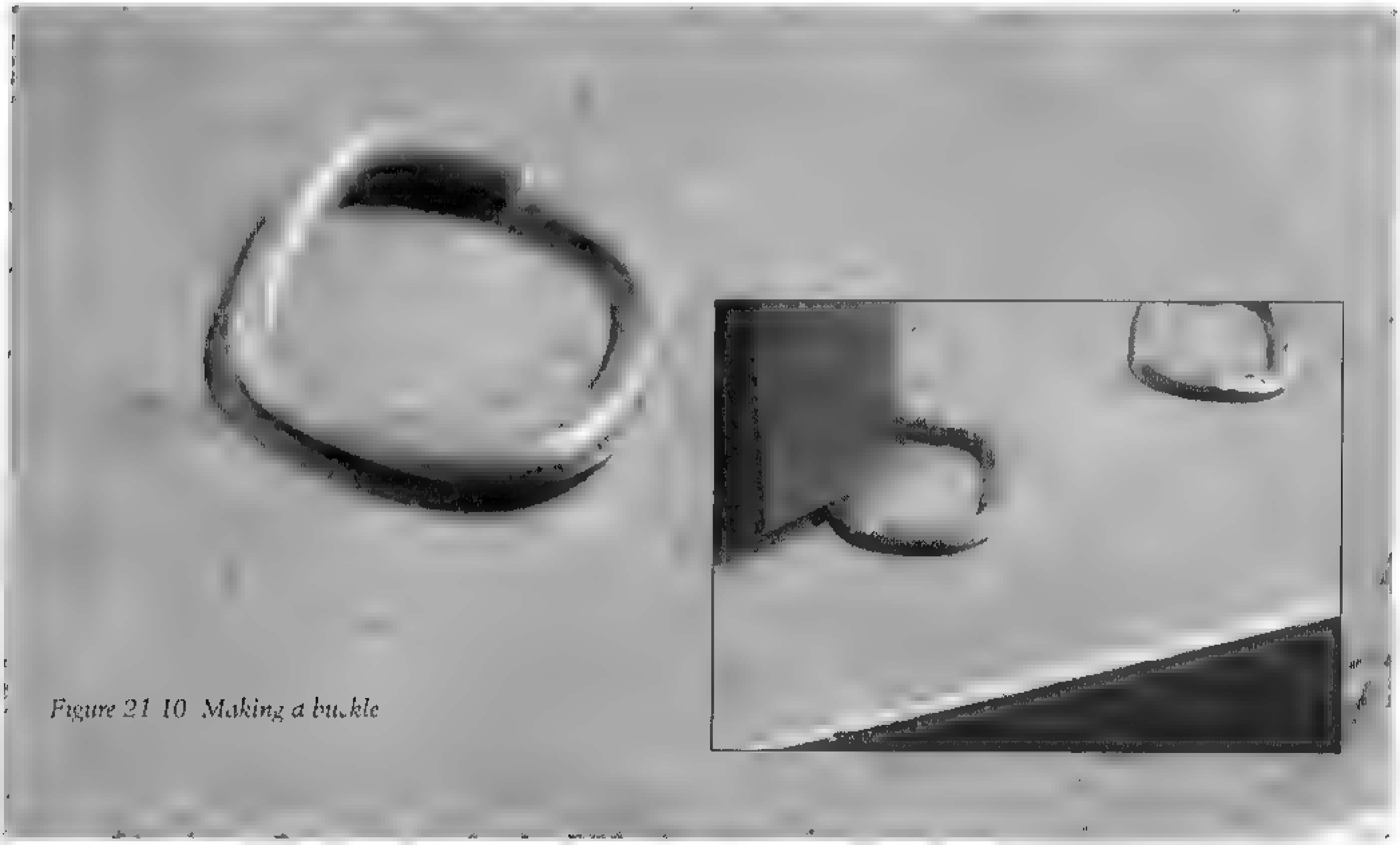


Figure 21 10 Making a buckle

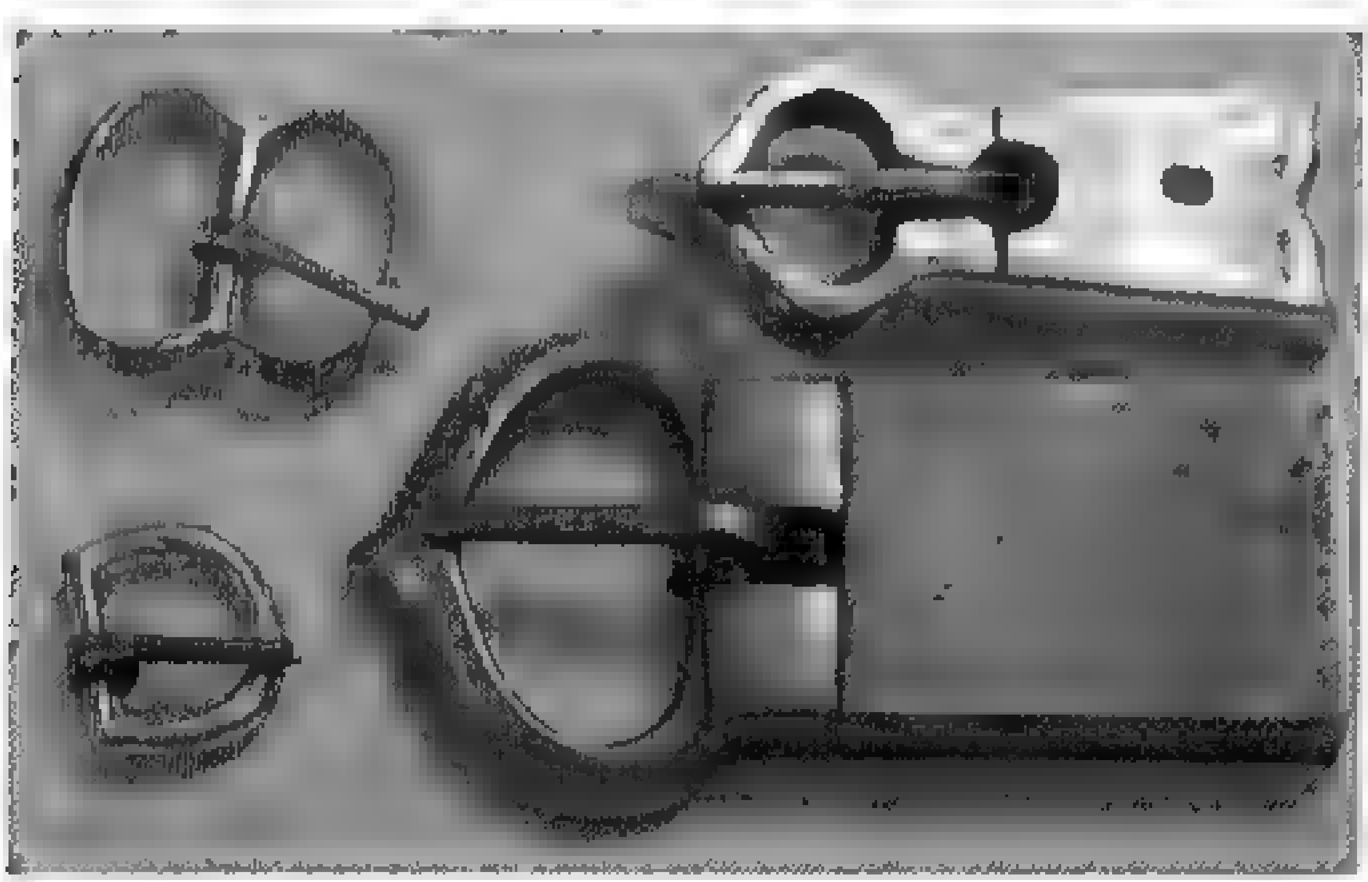


Figure 21 11 Reproduction buckles in copper allow are now available from various craftsmen Clockwise from the upper right corner: a silver buckle by the author, c 1350, narrow belt buckle by Brent Junkins bronze belt buckle, c. 1350, unknown craftsman; pewter accessory buckle by Robert MacPherson.

Figure 21.12. Thanks to amateur archeologists throughout Europe, authentic medieval buckles are available on the open market at a very low cost. These buckles from the author's collection serve as excellent casting masters. The first pulls from the mold can be cleaned up and a new run made, insuring medieval designs at a low cost.

Chapter 22

Grinding and Polishing

Possibly the most satisfying step in the process of creating a piece of armour is the grinding and polishing. All of the roughness is eliminated in favor of a smooth, brushed finish. Something of the piece's final power suddenly jumps out of the scale and facets, and the magic is at last revealed.

Cleanup and finishing after hammering takes place in two broad steps. The facets and irregularities in the piece are removed using an abrasive wheel, belt, or disk. The result is a smooth, brushed finish that can be fine sanded or polished to the desired level of shine.

HISTORICAL EVIDENCE

An examination of the inside surface of 14th century helmets reveals an exceptionally rough, irregular surface that would seem to indicate that pieces were heavily ground rather than finely finished from the hammer. They would then be (optionally) heat-treated, ground, and polished, where very aggressive grinding would provide the desired surface finish. This evidence seems to suggest that many 14th century pieces were in fact only bouged rather than planished. Additionally, since iron or steel sheet was formed by manual hammering of iron billets into sheets, the thickness

Opposite page: Figure 22.1. An armourer grinding on a helmet

Figure 22 2. Some finishing was likely done with large files, while other work was done by professional polishing mills.

likely varied slightly when the armourer received it.

Medieval armourers doubtlessly relied partly on large files to "sand" or grind their pieces, as is shown in iconographic evidence, but it is likely that the bulk of the finish work was done on water-powered wheels—mills that were often workshops in their own right, sometimes operating independently and sometimes under the ownership of an armourer. The large two-handed files that were used were probably produced in different grades, much as modern files are produced in rough, medium, and fine grades.

Polishing mills—at least in Italy—were often situated near rivers, probably to take advantage of the water based power source to drive large polishing wheels often illustrated in 16th century sources. These wheels, to which was attached a cloth or leather belt, were sometimes as much as 6 feet in diameter. The belt could be coated with glue and an abrasive painted on.

Modern armourers have the luxury of prefabricated belts, wheels, and disks to help with this process, yielding great speed in the whole grinding process. Polishing is usually done with compact cloth wheels coated with various kinds of abrasives that can cut aggressively or polish, depending on the speed of the wheel, hardness of the buffing surface, pressure applied to the armour, and specific compound used. A whole range of compounds are available that can provide finishes from a rough satin to a flawless mirror polish.

How Much Polish Is Authentic?

We don't really know how most armour was finished during the 14th century, though there

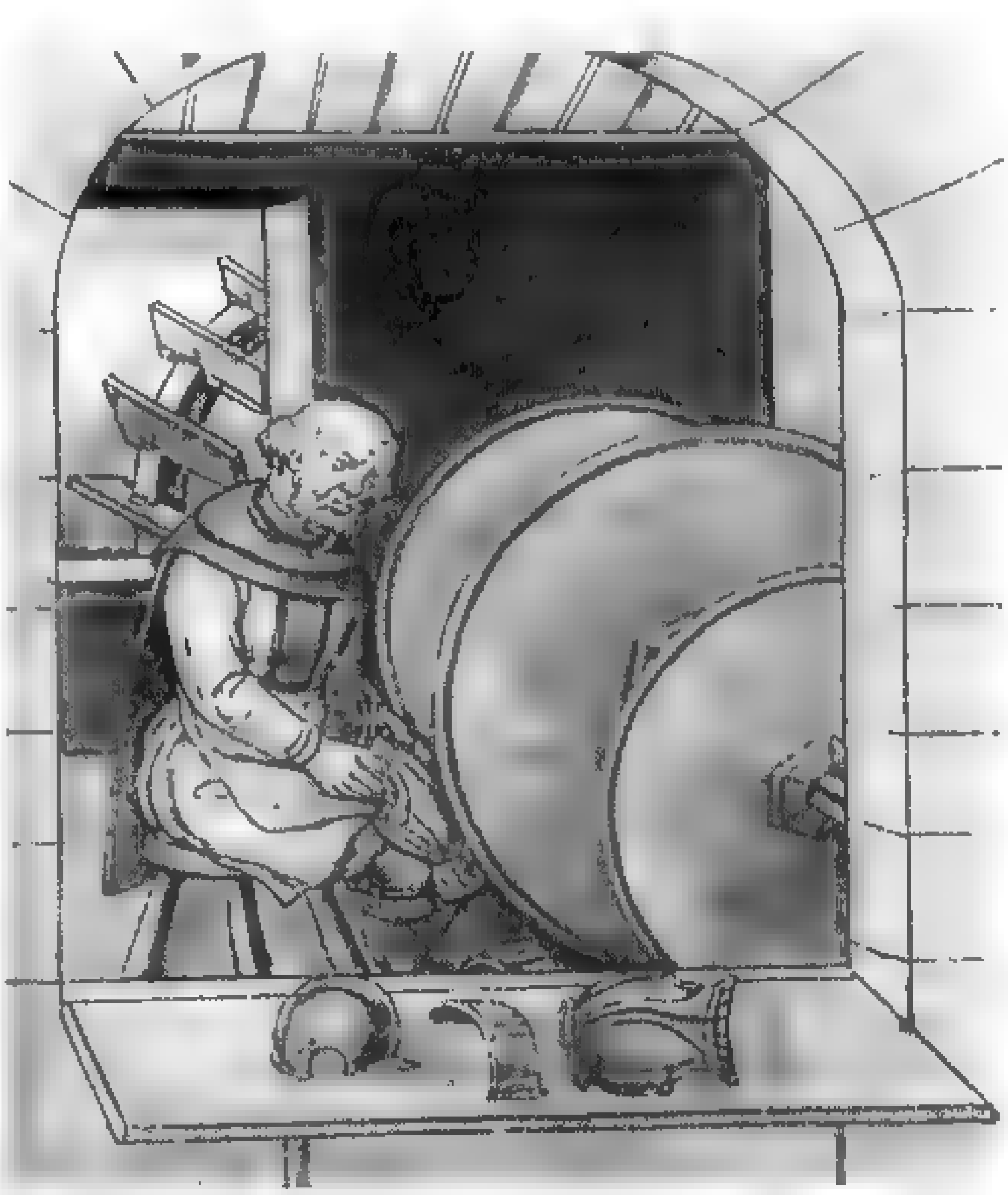


Figure 22.3. An armourer polishing or grinding using a water-powered wheel, from the Hausbuch der Mendelschen Zwolfbrüderstiftung, c. 1571. Although the illustration does date from the 16th century, earlier polishing mills were located on rivers, probably to harness the water in the same or a similar manner

are a few tantalizing clues remaining. The Milanese armour found in the Sanctuary of the Modanna delle Gratzie,[2] discovered undisturbed *in situ* since the 15th century, was covered in paint and so retains many unrestored features. Several helmet skulls, still covered by their wrapping plates, revealed near mirror polishes. It is likely that this bright finish was reserved for the better harnesses, as the delle Grazie armour mostly bears the marks of the finest Milanese craftsmen.

Medieval finishes as shown in illuminations and paintings seem to range from "rough from the hammer" on 16th century munition armours (fig. 1.11) to satin finishes (probably from 320–600 grit or finer) to high mirror polishes.

Unfortunately, modern steels contain alloying elements and are seldom heat-treated, yielding finishes that are notably different from the medieval originals. If the metal is not heat-treated or tempered, a high polish will often be "whiter" than a similar piece that has been

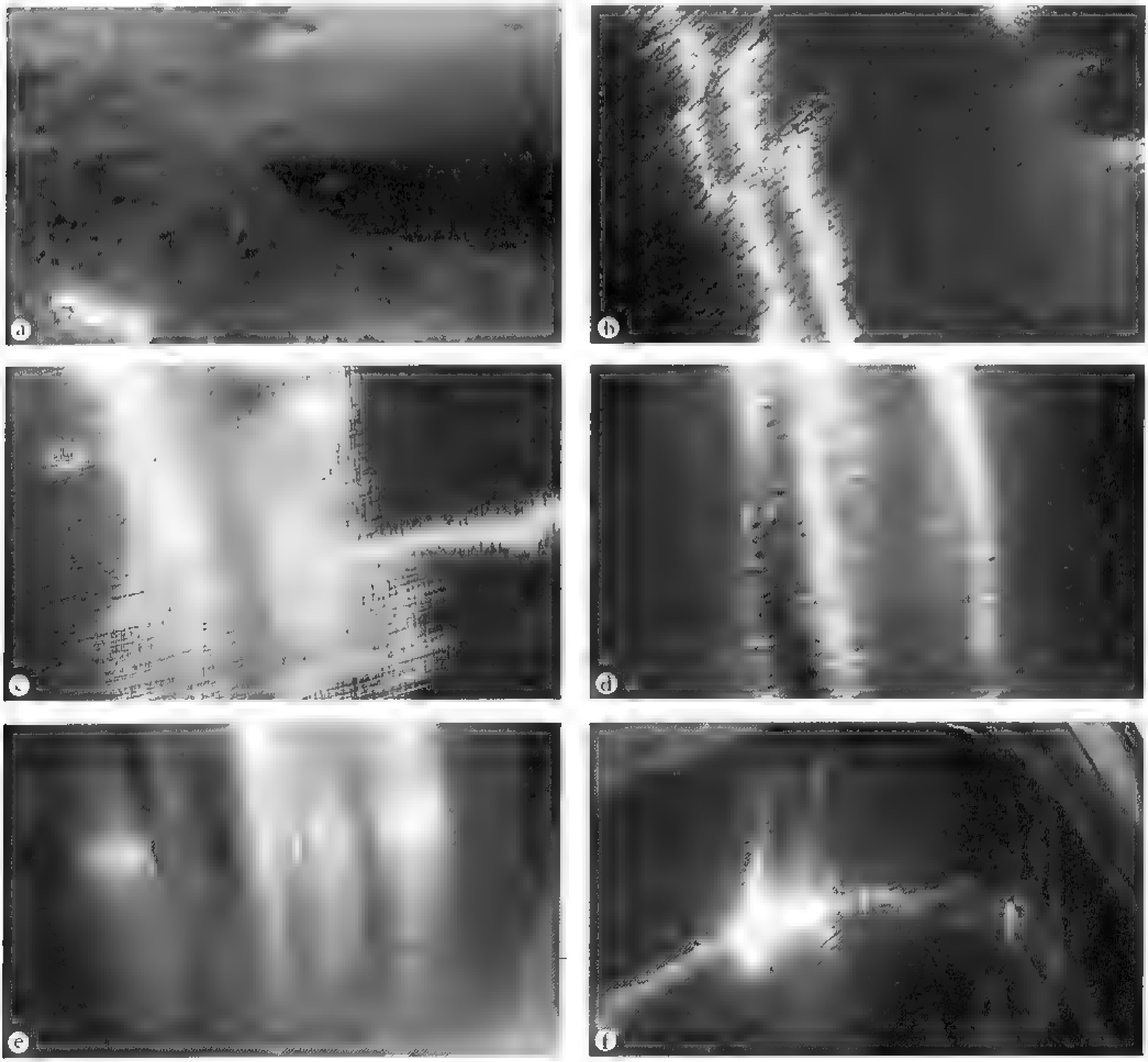
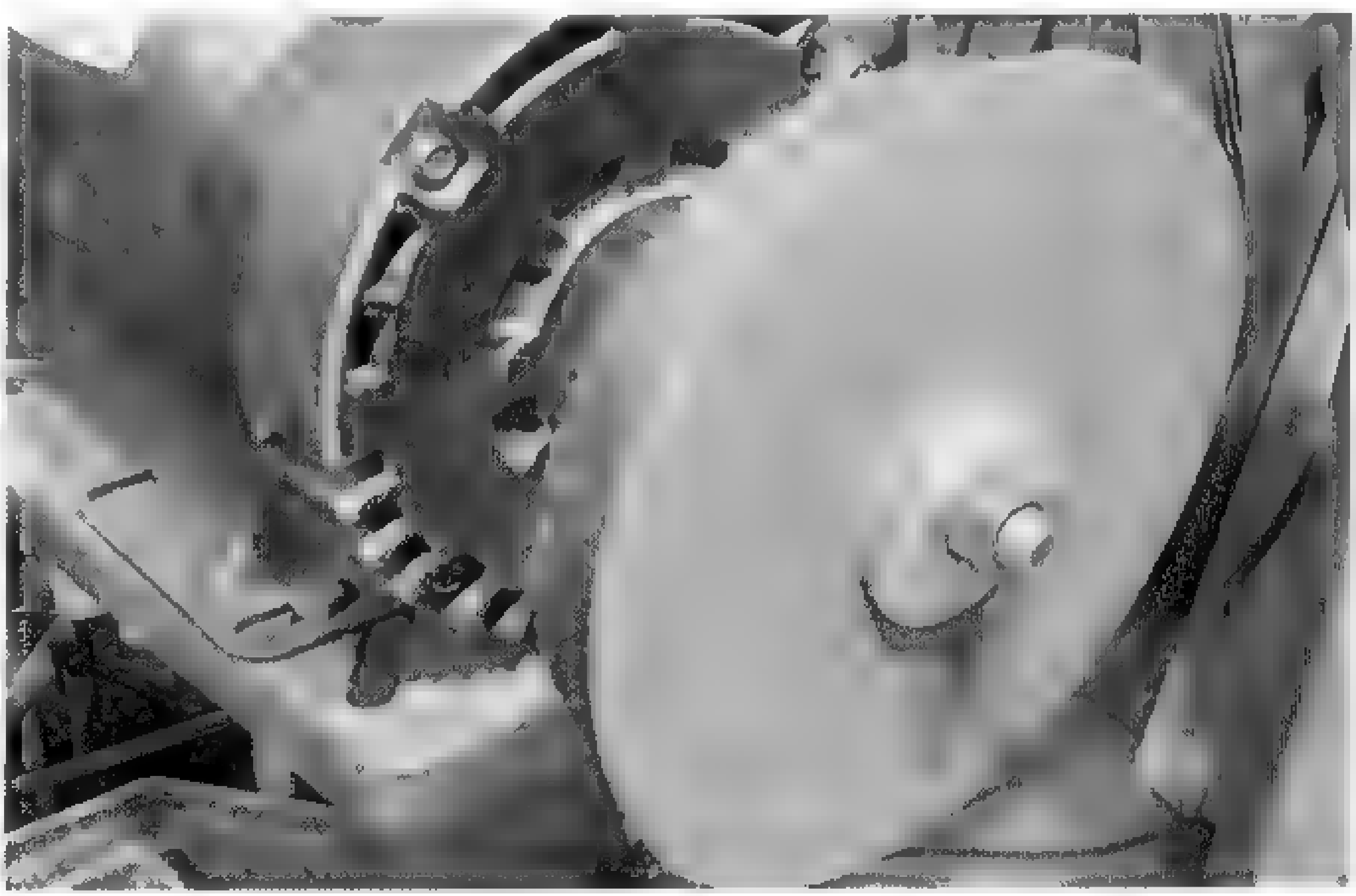


Figure 22.4. A piece of work from rough to finish.

Figure 22 5. Working directly on the contact wheel (left) and on the flexible back (right)

Figure 22 6 For most novice and intermediate armourers, grinding can be accomplished economically with the use of common aluminum- oxide sanding disks sold at most hardware stores. The disks are simply attached temporarily to the outside edge of a buffing wheel, which acts as a kind of flexible back



through the heating process. Authentic armour polished to a high gloss has a more gray appearance than its modern equivalents, though of course this depends on the steel, the methods of working and hardening it, and the compounds used in the polishing process.

GRINDING

All pieces must be ground to remove the hammer marks and prepare the surface for polishing.

In order to achieve a high polish, the hammerwork must be clean. When the scratches from a fine sanding pass are removed, every flaw in a piece is revealed. As such, pieces that are intended to be mirror polished should be superior in their craftsmanship with regard both to hammerwork and sanding. Sanding will not correct poor work with the hammer; the price for fixing a flaw with the sander is paid in terms of metal thickness, which in turn weakens the final piece.

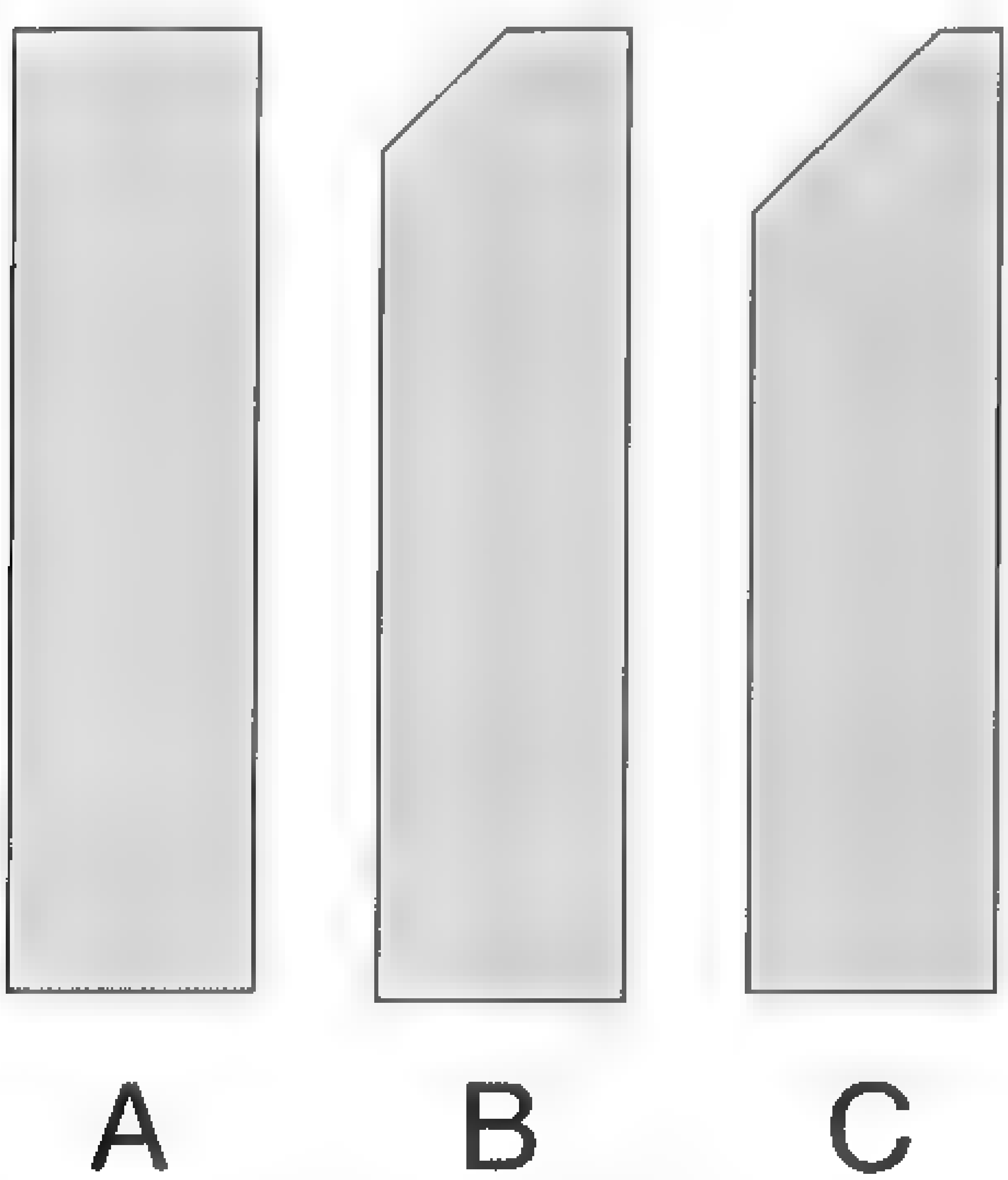


Figure 22.7. After the edge is smoothed, a bevel should be added to define the edge prior to buffing. Use care not to go too far or a knife edge can result. In these side-view cross sections, (A) represents the smoothed edge, (B) the correct amount of bevel, and (C) overbevelling to a near knife edge

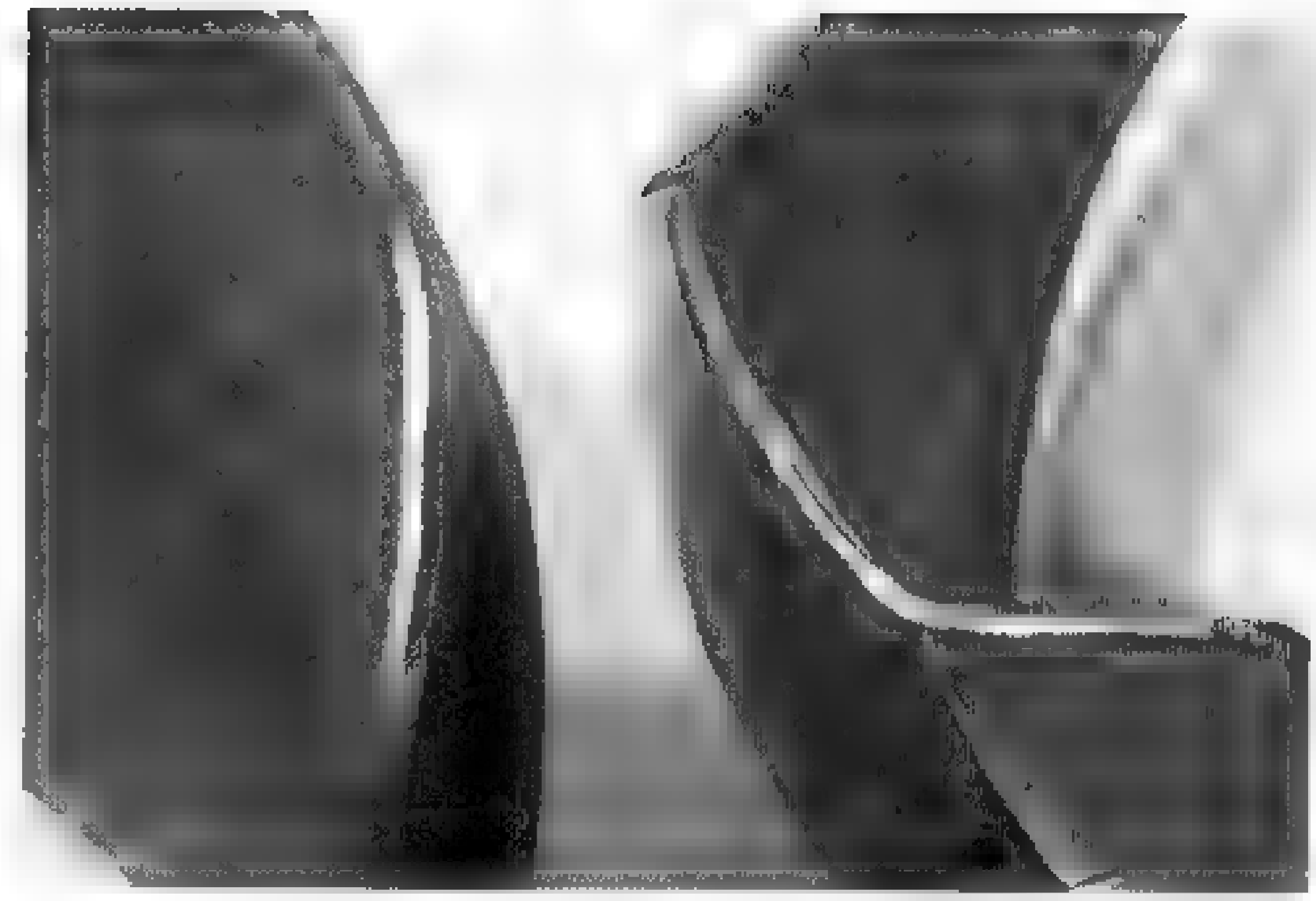


Figure 22.8. Comparison of a well-finished and a poorly finished edge

Grinding Technique

Once a piece has been finished from the hammer, it can either be heat-treated or ground directly. Grinding, or sanding, should be done such that the sanding grain is uniform and done in a pattern that is pleasing to the eye and easy to polish using cutting compound or finer-grit abrasives.

The basic technique uses a series of abrasives to gradually refine the smoothness of the plate's surface. Generally speaking this is done in two or three passes with an aluminum-oxide based abrasive belt or wheel. I generally start with a brand-new 100 grit belt, working the piece over until the grit begins to soften, ending up with a fine, smooth finish. On rougher pieces such as helmets (where there is often a weld to remove), I start with 50 grit and then progress to the 100 as usual.

The result of each sanding pass will be a surface grain or scratches. The uniformity and orientation of the grain will determine how clean the work is; the object is to sand the work such that all the sanding lines are arrayed in the same direction. This takes a degree of touch that must be learned whether you're working on a flexible-back belt sander like the Burr-King or on a sanding disk.

Grinding and Deburring Using the Burr-King

The Burr-King and similar sanders are useful in that they feature both a firm contact wheel

and a flexible back (fig. 22.5). The contact wheel, which is used for aggressive sanding, can even be improved with the addition of a serrated wheel for *really* fast cutting.

For a normal plate, use the contact wheel for the first pass finish (fig. 22.5 left). Then move the plate up onto the flexible back (fig. 22.5 right) to smooth out the facets that usually result from work on the contact wheel.

The Burr-King uses standard 2 x 72 inch belts that are inexpensive and easy to replace. Using the tracking knob, the belt can be moved from right to left in reference to the contact wheel. By moving the belt just slightly to the outside and exposing its edge, you get an additional, exceptionally useful surface. Belts can be damaged if the metal is pressed into the edge, though they can simply be cut to thinner widths if they fray or if a narrower belt is needed.

Grinding and Deburring Using the Flexible Sanding Disk

If the workshop isn't fortunate enough to be equipped with a sanding tool such as the Burr-King, a buffing wheel and inexpensive flexible disk will serve.

Aluminum oxide disks can be found at most hardware, paint, or welding supply shops. Most armourers use the 7 1/4 inch size, backed by a 6 inch buffing wheel. The disk is tightened down with the washer and nut and the face and edge are used for both aggressive cutting and final sanding (fig. 22.6).

Regardless of which tool is used, the resulting faceted finish should have the grain flowing all in one direction. To insure that all rough-sanding grain is removed as successive grits are used, I like to switch directions each time, sanding across the grain. With each pass, all sanding marks from the previous efforts should be completely removed.

Finish Sanding the Edges

When the surface is finished, the edges should be carefully sanded or filed, then polished. Many intermediate armourers somehow ignore the edge treatment, but the edges should be sanded and polished just like

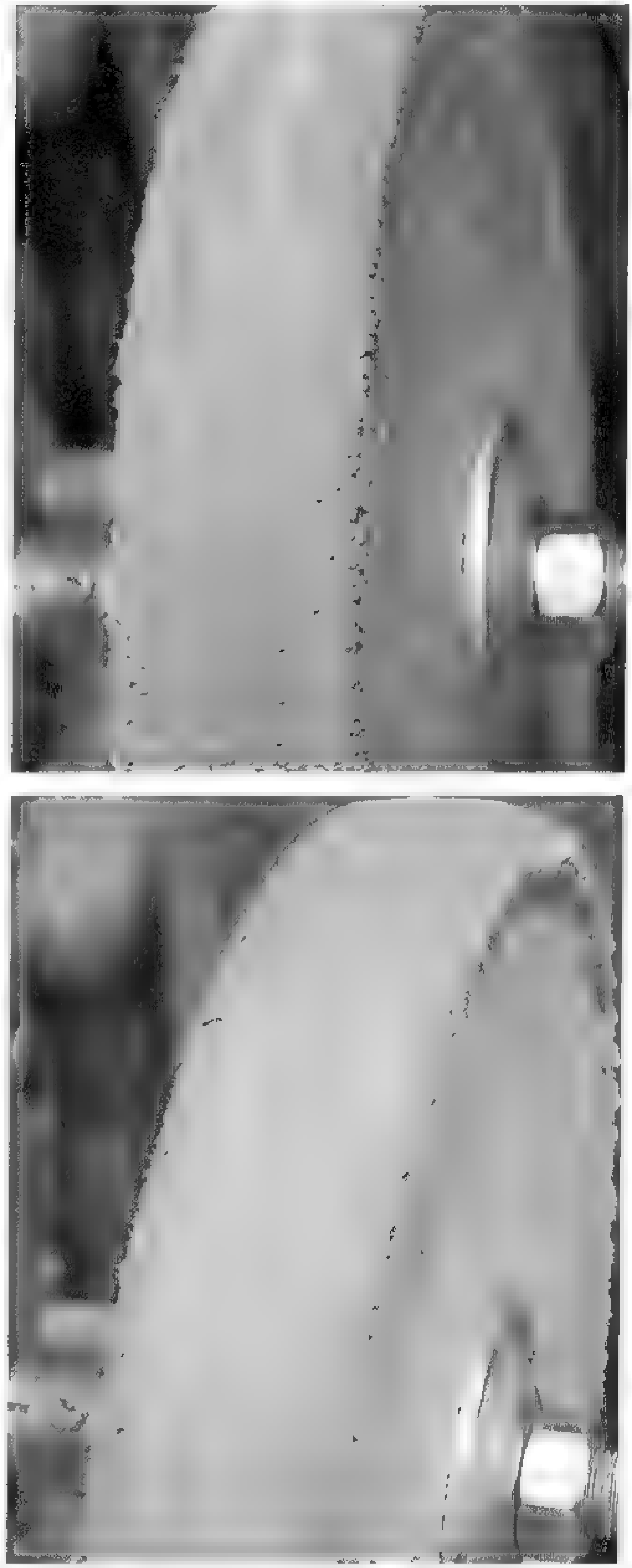


Figure 22.9 A wheel needing recharge before (top) and after (bottom)

any other area of the armour. Files can also be used to finish the edges (fig. 22.8).

The edge is first sanded to provide a smooth flow of metal along its length. Use a good light source and track it along the edge, looking for imperfections. When this step is complete, the edge should be smooth both with a visual inspection and to the touch. Next, the edge is knocked off to better define it and to reduce its sharpness—but be careful; too much bevel will result in a knife edge (fig. 22.7).

POLISHING

Once the grinding is complete, the next step is to use finer abrasives to further smooth the plate's surface. Modern buffing compounds—both grease-based and so-called "greaseless" abrasives—are used in conjunction with hard cloth or felt wheels to provide a final finish.

Most modern armourers polish their work in two steps. The first uses either a brush-on compound or an aggressive greaseless cutting compound that quickly reduces the sanded surface to a satin finish. One or more finishing compounds are then sometimes used to bring out a mirror polish.

Unfortunately, polishing is not as easy as the above two paragraphs might make it seem. Developing a touch that polishes without leaving streaks is not an easy task. Some hints and guidelines are provided below, but the bulk of the expertise simply requires patience and practice.

Applying the Compound

A greaseless compound such as is sold by Formax or the Knife and Gun Finishing Company is often used for rough polish work. It comes in a variety of grits, but the 80 grit

Figure 22 10. Applying compound

seems to work best, serving both as an aggressive cutting agent (if you push) or a fine satin finish (if you use less pressure). The compound comes in plastic tubes but hardens with exposure to air, so it must be kept wrapped between uses or the whole bar will dry out and become useless. I strongly recommend 1 inch, tightly woven buffing wheels with a diameter of not less than 8 inches. If wide buffs aren't available locally, then several narrower ones can be used together to get the needed surface area. At least two wheels will be needed, since one is generally drying while the other is in use. During use the compound gradually leaves the wheel, so it must be recharged from time to time (fig. 22.8).

The usual way to apply compound to the wheel is to turn the motor on with the wheel attached and then apply compound liberally with a brush until it is an even, rich red color (fig. 22.10). Turn the motor off and further coat the wheel with the nearly liquified. Remove this wheel, place it nearby, and select the second wheel, which should be charged and ready for use. Each wheel needs from 5 to 10 minutes minimum to dry.

Another method is to heat the compound in a shop-dedicated microwave oven. Do not cook food in the same oven, as the process could introduce toxins to the oven. The compound is liquefied and then brushed on the wheels and allowed to set overnight. The resulting wheels should do many square feet of plate so long as the edges are not caught and will cut more aggressively than compound that has only dried for a few minutes.

A third variant uses brush-on compounds to achieve a similarly abrasive cutting surface. This compound, sold not in tubes but in small buckets, is simply brushed on and allowed to dry overnight.

I have had some success with the Formax brand of set-up wheels, which do not leave as much residue or dust in the air, keeping the workshop a bit cleaner. Also, they tend to last longer. The abrasive is much more aggressive, however, so the armourer should work through 80, 120, and finally 200 grit to get to an even, satin finish.

Using a Cutting Compound

Once the wheels have been coated and the plates finished to the final sand, they can be polished using the cutting compounds suggested above.

To achieve an even buff, the polisher should strive for consistency and must have patience. Rushed polish work will result in a streaked, uneven finish that has a crude, distasteful appearance. Only practice and patience will yield the right angle and pressure.

Each buffing row should be overlapped on the last, and the polisher should go from one edge to the other, resisting the temptation to work only on one section. Do not use too much pressure on the wheel; a firm but not oppressive amount of force will allow the cutting compound to cut aggressively, yielding a shower of satisfying sparks. As the compound wears the sparking will diminish until the compound has finally been spent (fig. 22.8), at which point the wheel must be recharged. Conversely, too light a pressure will result in streaking, as will too much speed across the metal. The right rhythm is an even pressured, fairly slow side-to-side motion where each row slightly overlaps the preceding one.

Satin Finish

Once the rough cutting pass is finished (fig. 22.4e), another pass can be made with slightly less pressure. Some armourers prefer to use a slower motor for this phase (1750 RPM) and sometimes softer cloth wheels to help with the desired brush finish. Another technique is to use Scotch-Brite belts or wheels for the final finish. Each technique can yield a fine brushed surface.

Mirror Finish

Some armourers prefer to leave their armour satin-finished. This is fine, but for reenactors it is hard to maintain because the finish is susceptible to oxidation, resulting in rust. In order to combat rust, a higher quality polish is recommended since it is easier to care for.

To achieve a bright finish (fig. 22.4f), a white or stainless compound should be employed. These compounds are usually grease-based, unlike the cutting compound

recommended above, but they require no set-up on the wheel and do not have to dry before use. Consequently, only one buff is needed for the high-polish compound, but it should be a dedicated wheel since residue from the more aggressive compounds will mar an attempted high polish.

The mirror finish can be done to any number of levels, depending upon how many intermediate steps were taken before the high polish begins. If the armourer has stepped carefully through the sanding grits say from 100 to 220, then spending some time with the cutting compound removing all of the 220 grit sanding grain—then the result of the high polish will eventually be a near mirror finish. If, as is more likely, only the 100 grit was used, followed by work with the cutting compound, deep scratches will probably remain This grain will not necessarily detract from the final appearance as long as the sanding work was done evenly. The result in this case will be that the scratches and the surface are polished equally, still providing adequate defense against rust but without the mirrored effect.

A Note on Polishing Brass and Bronze

Brass and bronze trim can generally be polished using a very light pass with the cutting compound, followed by the high polish. A stainless compound is aggressive enough to remove scratches made by the cutting compound yet polishes well enough that the final product is an attractive bright color.

ENDNOTES

1 I suspect that the finer 15th century helmets are more refined in their hammerwork but the proof must await further study.

2 Mann, James G "The Sanctuary of the Madonna delle Grazie, with notes on Italian Armour of the Fifteenth Century." *Archeologia*, 80, 1930, pp 117-142

Chapter 23

Decorative Enhancements

While the skillful forging of plates in iron and steel can be more than sufficient to create pieces of surpassing beauty, medieval armourers used a variety of techniques to decorate their work. Beyond high polishes, pieces were at different times blued or blackened, painted, decorated with variously produced latten trims, engraved, etched, chased, and gilded.

Not all techniques are appropriate to pieces of a particular period, and the novice or intermediate armourer should avoid the seductive allure of "glitz disease," where mediocre hammerwork is covered by a veneer of decoration. While this decoration does draw the eye from poor hammerwork, it is unlikely that it will fix poor lines, fit, or other critical elements that form the basis of the piece's quality. Without these foundation elements, décor just makes the piece busy.

Applied appropriately to a quality piece, however, enhancements can add to its dramatic value and give the armour/artisan more tools for expression.

Opposite page: Figure 23.1. While clean lines are important to the quality of a finished component, a crisp piece can be enhanced by a variety of techniques. Decorative brasswork, etched edging, and cast rivets add extra richness and impact. To be strictly correct many of these decorative elements should be engraved rather than etched

PAINTING

Although few examples remain, there is evidence of armour being painted as early as the 12th century. Some early barrel-style helmets were painted, a few

remaining examples seem to have carried a heraldic theme.

The primary objective of painting would be to prevent oxidation, but two other reasons are compelling. The first is to cover rough workmanship—pieces that have been left rough from the hammer can be quickly coated with brushed-on paint. This practice was common throughout the 13th, 14th, and 15th centuries, applied variously to bascinets, sallets, and chapels-de-fer.[1] The second was for heraldic display—there is evidence of helmets being painted in this manner from the 13th through the 15th centuries.

During the 16th century a particular style of armour, the "black and white" harness, was popular throughout Europe as munitions-quality equipment. These armours were made quickly, often left rough from the hammer (though not always) and embossed on the edges (probably using a swedge). Only then were the borders polished and the remainder of the armour painted black. The result is very striking.

I have found no documentary evidence for the type of paint used on the medieval originals, but modern reenactors tend to use brushed enamel paint because of its adhesion to the steel and its ready availability. The use of a metal primer is strongly recommended. Do not use spray paints, as they usually bond poorly and create too fine a coat that scratches off easily.

For protection, it is wise to coat the inside surfaces with primer or brush enamel, as the salty perspiration from the combatant will quickly rust the armour's interior.

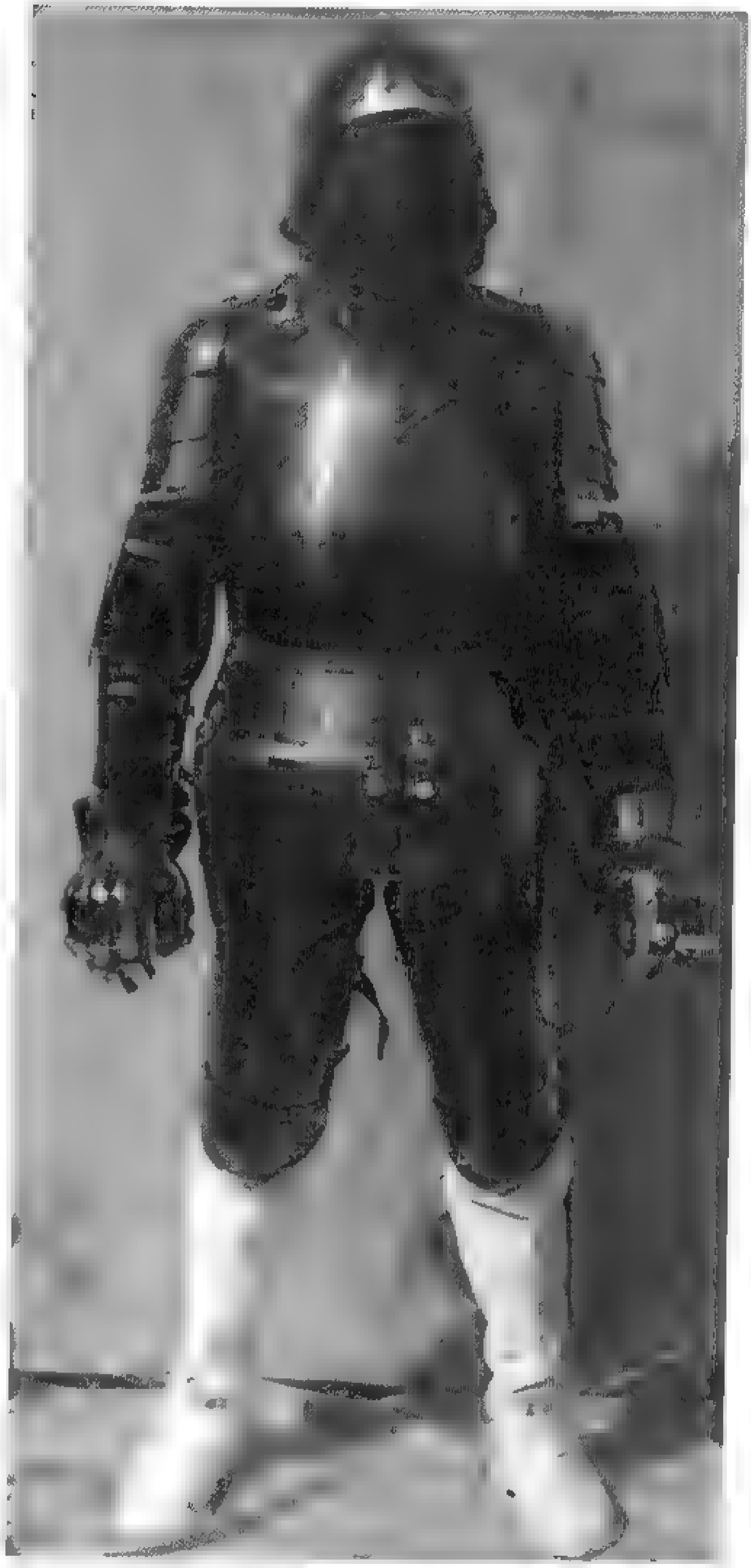


Figure 23.2. While usually reserved for armour from the middle 15th century and later, commercial black oxide treatments provide a glossy, attractive rust defense that resembles similar treatments seen frequently in illuminated manuscripts of the period. Armour by the author, 1986

BLUING AND BLACKING

The earliest reference I have been able to find for blued or blackened armour is from the 15th century. It is likely, however, that the technique was first used during the middle of the 14th century, since various forms of quenching in oil were attempted during this period, and the results from such attempts telegraph intended blacking treatments.

Fifteenth century manuscript illuminations frequently depict figures in battle in what appears to be black- or blue-treated armour, particularly in the Italian export style, but it is unclear to what extent this was an artistic

convention and to what degree armours were actually blued or blackened. I have personally seen only a single Gothic harness at the New York Metropolitan that was blackened, but there may well be others.

Steel can be blackened by heat alone, although there are scattered references to medieval processes using fats, ox gall, a mixture containing sulphur or antimony glaze, and even by pickling with various combinations of acid. Blacking might simply be a subset of modern chemical bluing, and certainly similar results can easily be achieved using commercial process, such as the so-called "black oxide" finish available commercially.

In all bluing, browning, and blacking formula, the intent is to produce controlled oxidation that creates a beautiful black luster while providing some protection against rust. I have used commercial blacking with great satisfaction even on mail, provided that the work is well done by the vendor.

To prepare a piece for blacking, all that is required is to polish the metal Indeed, it can even be assembled before the blacking is done. Attached pieces of brass or bronze will suffer only with a slight tarnish, which is easy to remove with the white polishing wheel. If the pieces are first surface-polished to a high gloss (scratches are permissible), then they should be in a similar state when returned from the oxide treatment. The backs of the pieces should be free from rust and paint before dipping.

DECORATING WITH BRASS AND SILVER

Throughout the 14th century, decorative borders, rivets, rosettes, and gatlings were used with striking effect to offset the rich iron grey of the armour's polished surface. Some of these enhancements were clearly used to secure cloth to the armour, covering the "white" surface with rich brocades and velvets, while others

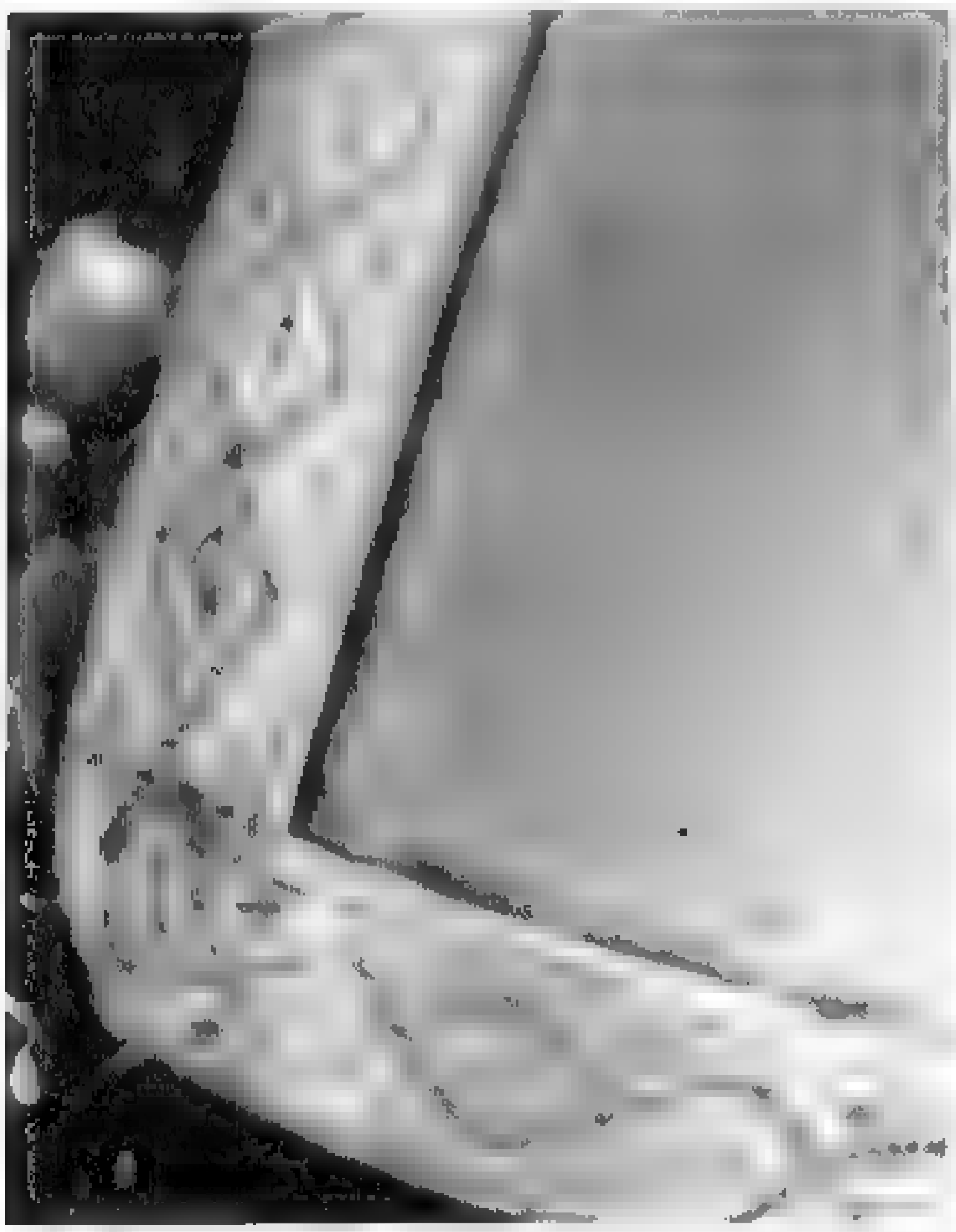


Figure 23 3 Engraving on the Lyle bascinet, preserved at the Royal Armouries in London Note the woven geometric pattern Such patterns make excellent space-filling for latten borders and can be replicated through engraving, etching, or even punchwork, although engraving is the most correct (Photo © Board of Trustees of the Royal Armouries, detail of IV.470)

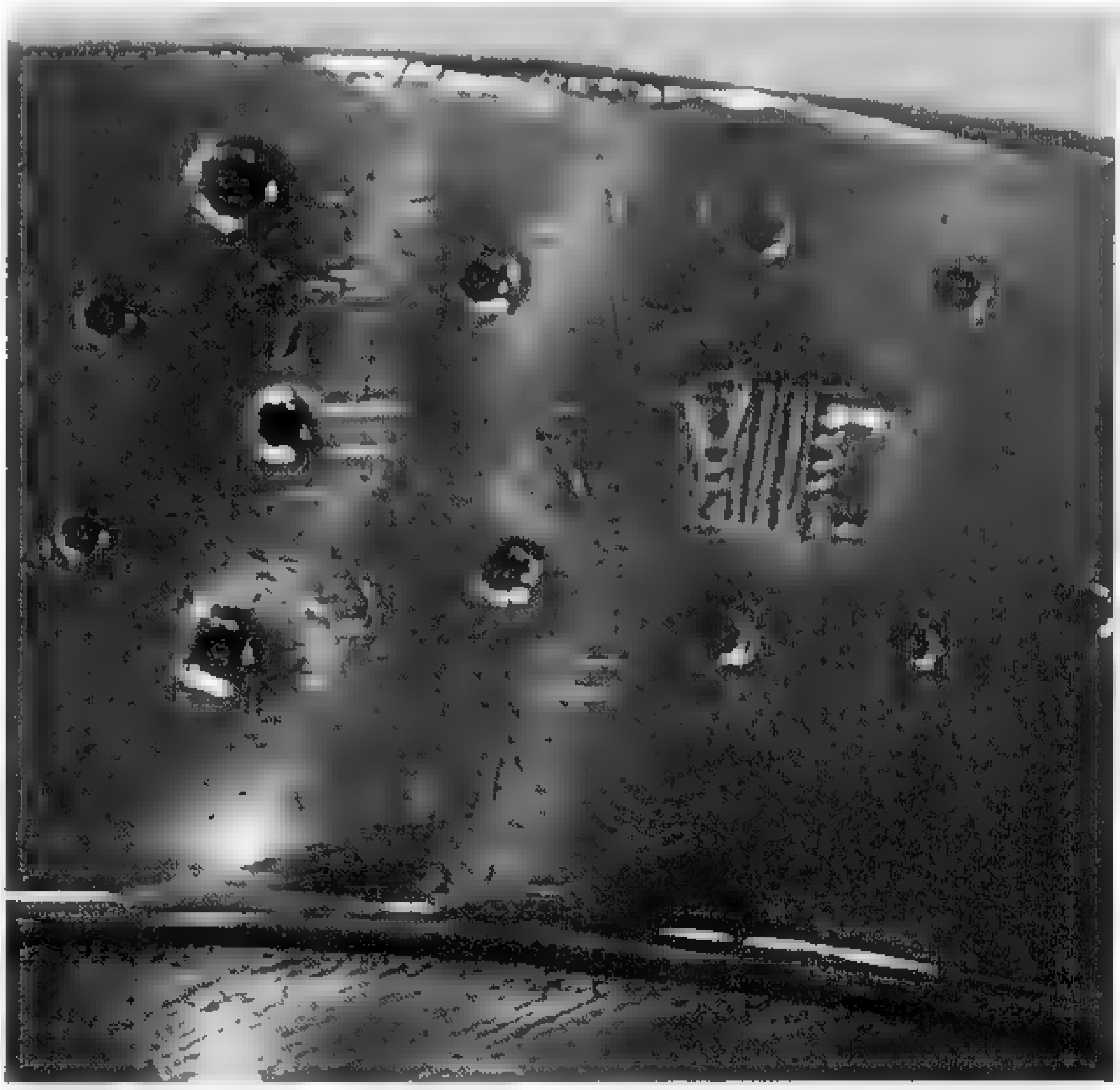


Figure 23 4. Although no examples of punchwork gauntlets have remained creating letters and patterns with decorative punches can provide a hint of the finer engraved examples. Gauntlets by the author, 1993

where applied directly to the steel. In both cases, the multicolor effect was a stylistic earmark of transitional armours and so can be used with great artistic effect on armour from this period.

Not only were some pieces decorated with pieces of brass or bronze, others were fashioned entirely from this material. Small plates—such as gauntlet metacarpals[2] or gatlings, small spaulders, and early besagews—could be artfully made in bronze or brass. Likewise, some components on German gauntlets from the 15th century were made from brass, skillfully embossed with surprising craftsmanship. When work-hardened from the hammer, bronze is as durable as wrought iron and so would be sufficient for defensive purposes.

Except for some throwback examples,[3] after the turn of the century the use of latten appears to have largely gone out of fashion save for use in rivets, embossed rosettes, and the borders applied to Lorenz Helmschmid's famous Gothic armours produced at the end of the 15th century.

EDGING

Armour on funerary effigies from the transitional period appears to have been decorated with edging that was enhanced with etching, engraving or cast into repetitive patterns. While most extant examples of this trend have been lost to us, there are a few outstanding pieces remaining that can tell us a great deal about the techniques employed.

Armour preserved at Schloss Churburg on the famous #13 and the Lyle bascinet now in the Royal Armouries collection feature this kind of decorated border, and a single piece of gilt and cast silver trim remains on a sabaton of Charles VI now preserved in the Chartes Museum.

According to recent scholarship by Mario Scalini, it appears that white armours were purchased from the armourer and then delivered

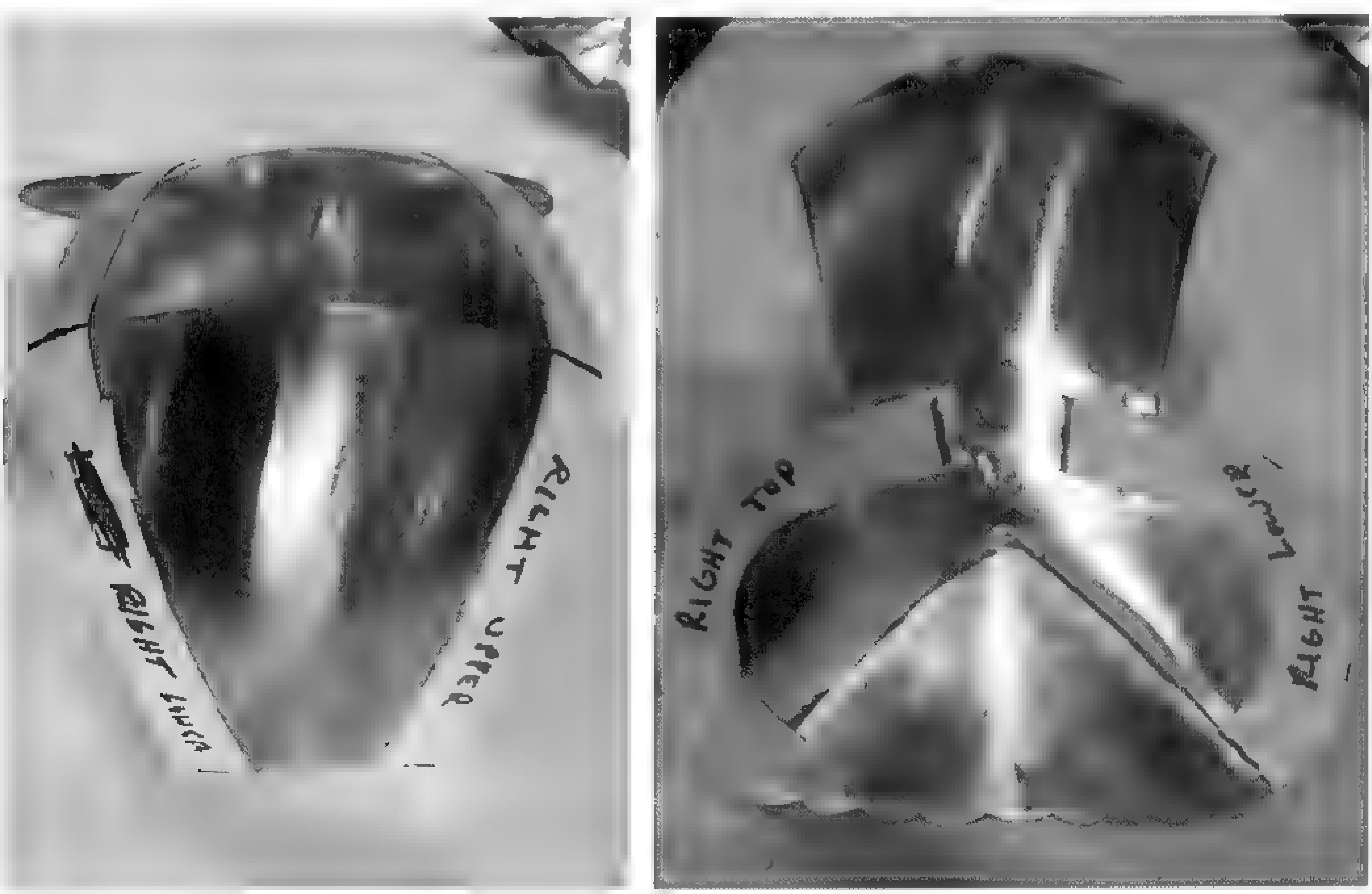


Figure 23 5 Taping around the edge

to a different craftsman to add the brass border. On the Lyle bascinet, the inside edging of the cut strips is less than perfectly straight, although because of the grandeur of the effect it is not evident except on the closest examination.

All of the borders from Churburg are engraved rather than etched. This does not necessarily preclude etching as an appropriate technique, but it is not documented as the engraving is. Similar gauntlets are also in the Wallace Collection (see fig. 33.1).

On the Lyle bascinet, the trim features a latten border engraved with a wandering geometric pattern of small zig-zag lines weaving between the rivet placements (fig. 23.3; a similar treatment appears on the gauntlets in the Bargello collection and has been reproduced through etching on the gauntlet pieces shown in fig. 23.1). On the #13 harness, the trim is engraved with a passage from the gospel of Saint Luke: "But Jesus passing through the midst of them, went his way." Mr. Scalini points out that this is similar to conjuring rings, frequently set with diamonds, that were intended to protect the wearer from adversity. It seems that various elements of a motto or popular phrases (the Wallace Collection gauntlets are an excellent example—AMOR—*Ave Mater Omnipotentis Redemptor*) would be an appropriate treatment, as would leaf or geometric patterns. Extrapolating from the remaining Churburg examples and funerary effigies, such latten borders might be placed at the metal's edges on spaulders, along breastplate edges, around couters and poleyns, at the bottom of the demi-greave or greave, perhaps at the top of the cuisse, [4] and around the helmet visor and face openings.

On the Lyle bascinet, the thickness of the border appears to be approximately 16 gauge, although examples on the Bargello gauntlets would point also to a much thinner metal used on the cuff, since the cuff plates on these fine gauntlets are embossed with round bumps to

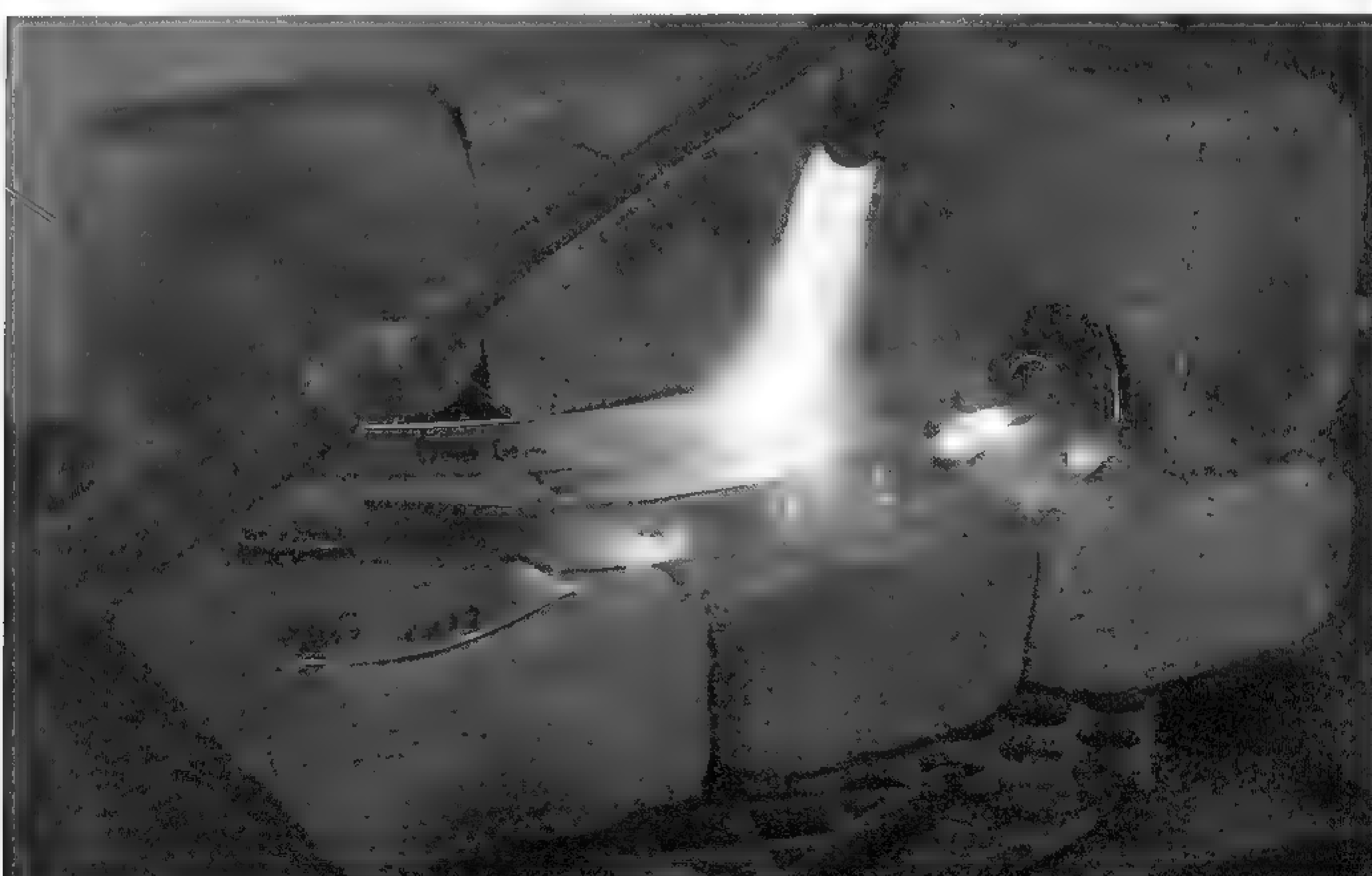


Figure 23.6 Annealing the brass

imitate rivet heads, something that would be difficult in the thicker materials required for edging. Materials of 18 and 20 gauge can easily deform when struck and often wrinkle with application and cause the border to detract from the piece rather than add to it.

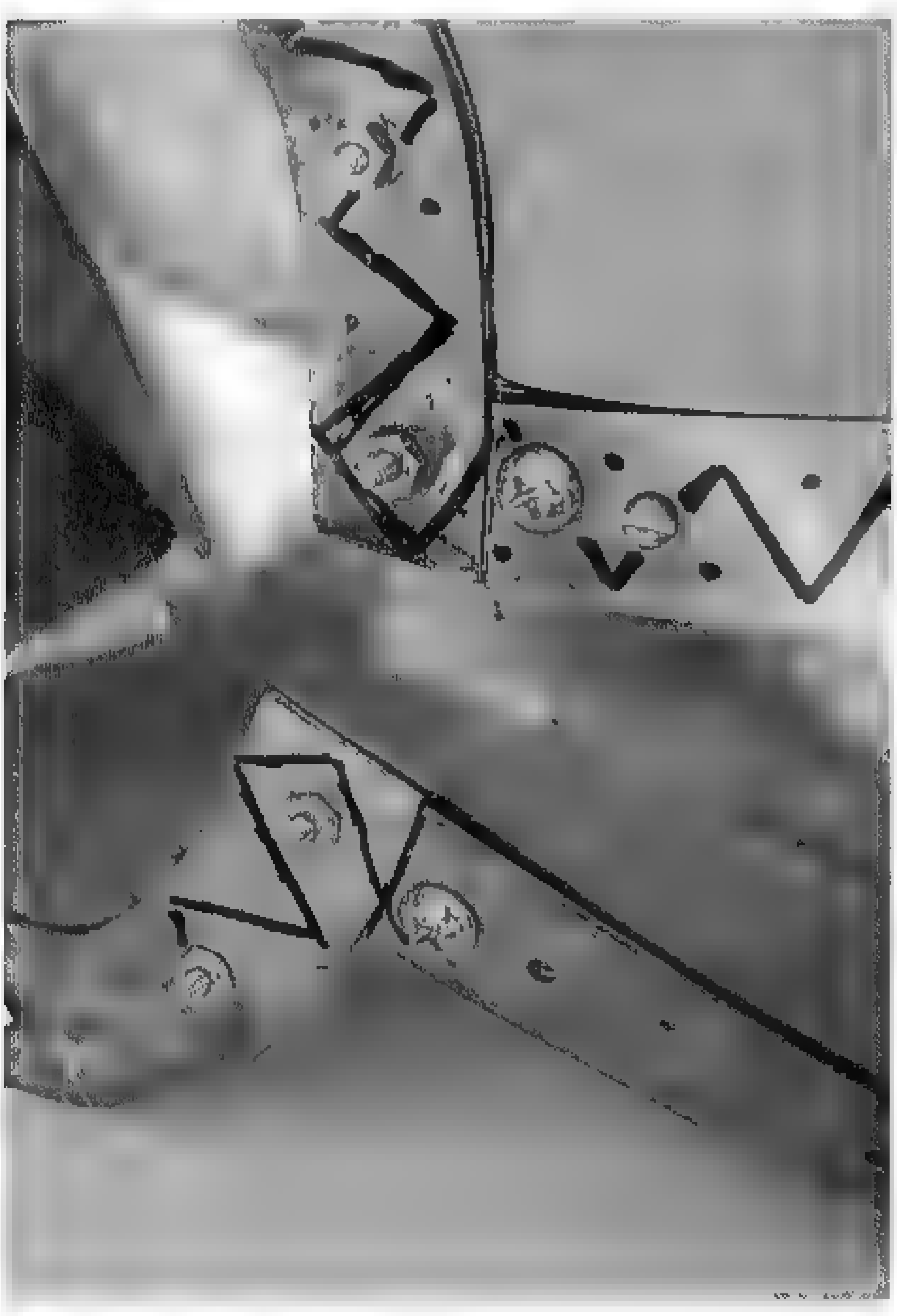
Modern armourers sometimes hint at this tradition by adding simple brass trims without decoration. I have also seen this trim decorated with punchwork and etching with great effect, although as mentioned earlier, strictly speaking engraving is the correct technique (fig. 23.15), while etching and punchwork are less pure in their interpretation owing to a lack of evidence for their use

Adding a Border

The first step to adding a border is to create a pattern. I use 1/2 inch masking tape, although 3/8 inch will also work. Cut the tape into small strips and, starting at one side, overlap it perhaps halfway over the last piece so that each piece overlaps the last from end to end (fig. 23.5). This tape is then marked and carefully peeled away. Since it is still sticky, place it on pattern-stock cardboard and simply cut out the pieces from 16 or 14 gauge brass or bronze sheet.

Carefully sand and file the edges, since part of the impact is caused by the finely finished edge forming a line of light against the piece's surface. This is another reason why thicker material works better, since 18 or 20 gauge material does not present much of an edge surface and the visual impact of the trim is significantly weakened.

The brass or bronze pieces, completely filed and ready for fitting, should now be annealed to soften them in preparation for the fitting (fig. 23.6). Remember that with nonferrous metals, annealing is done in a manner opposite of what is appropriate for ferrous metals in that



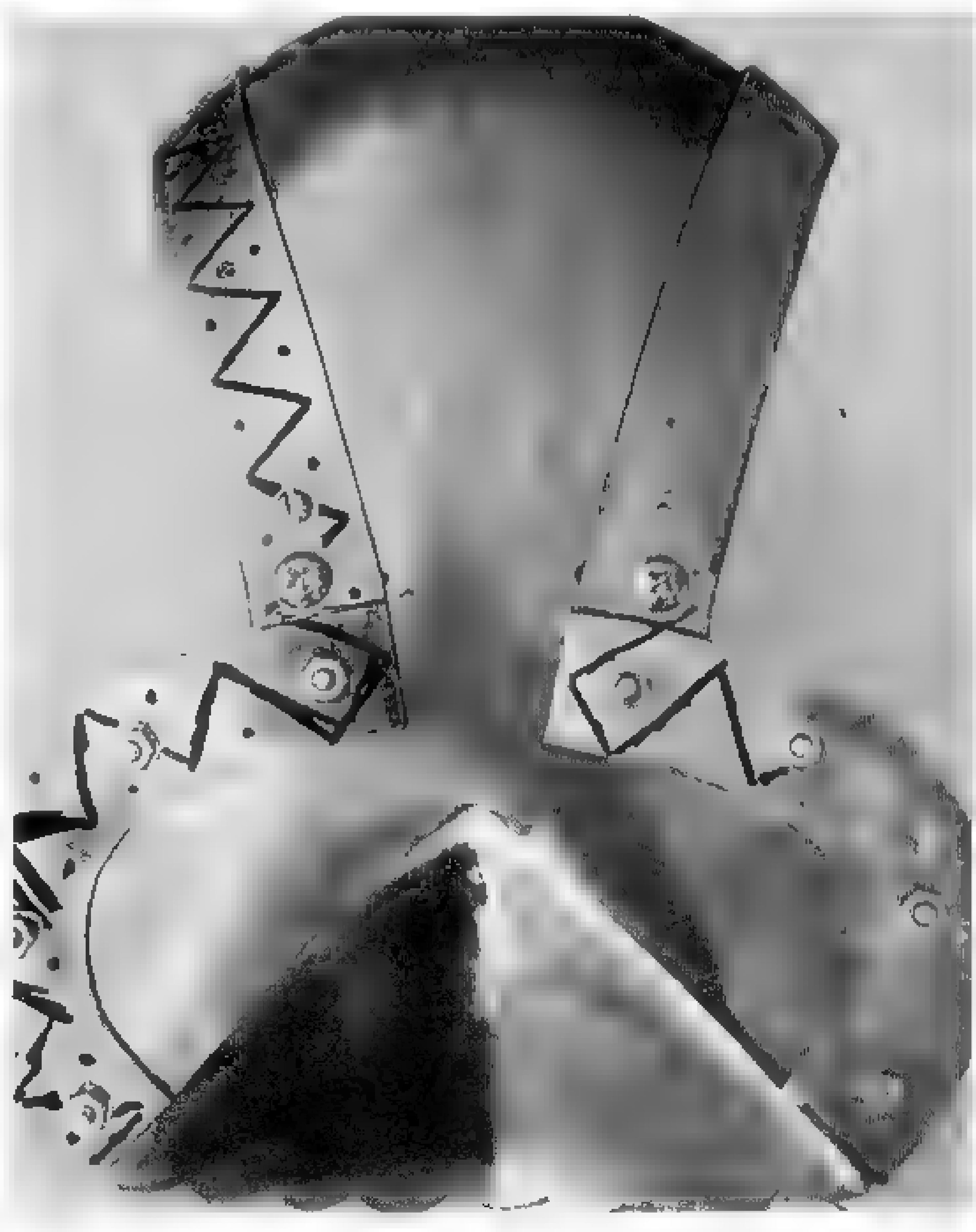


Figure 23.7 Trim fit onto a poleyn

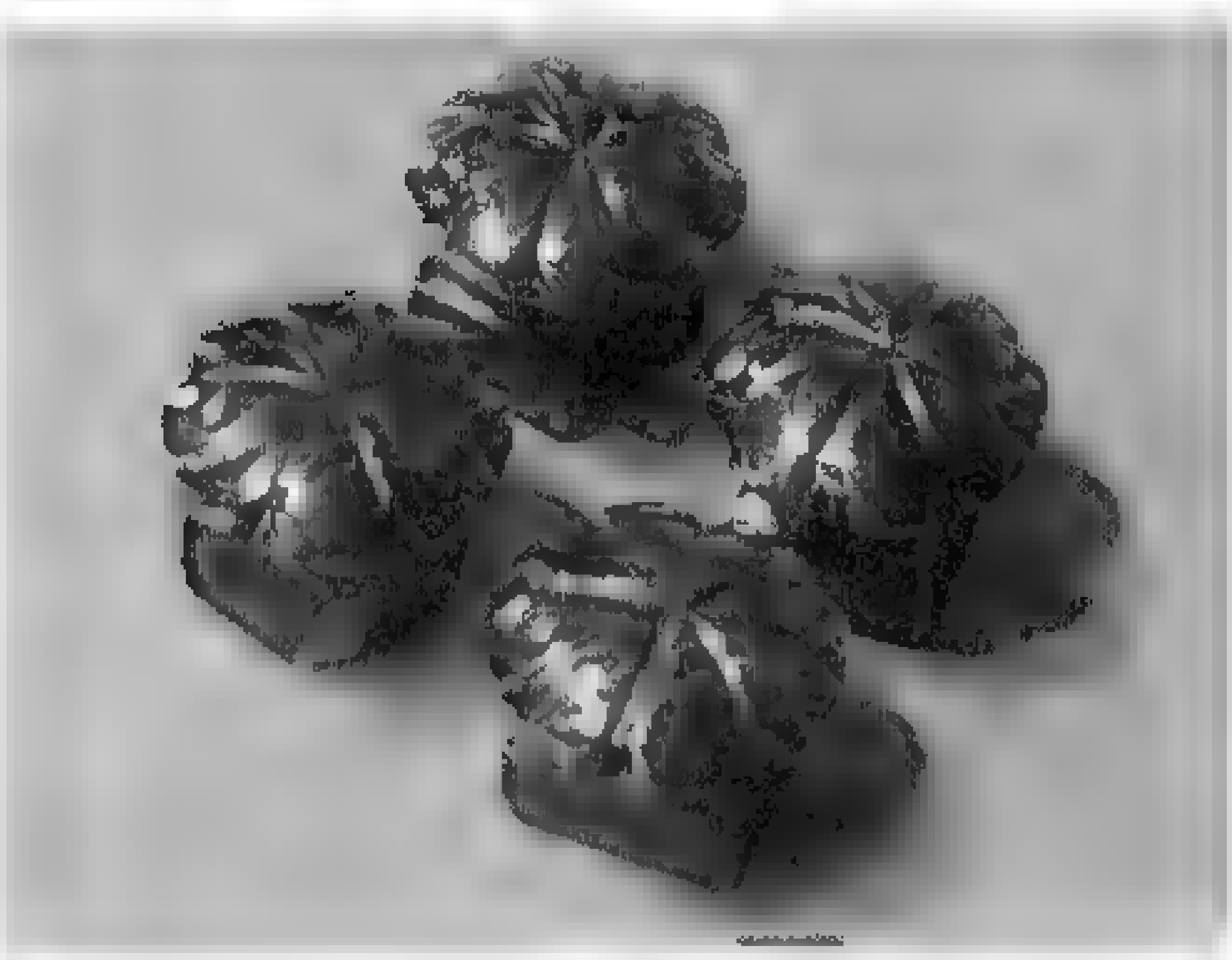


Figure 23.8 Decorative rivet heads made from bolts

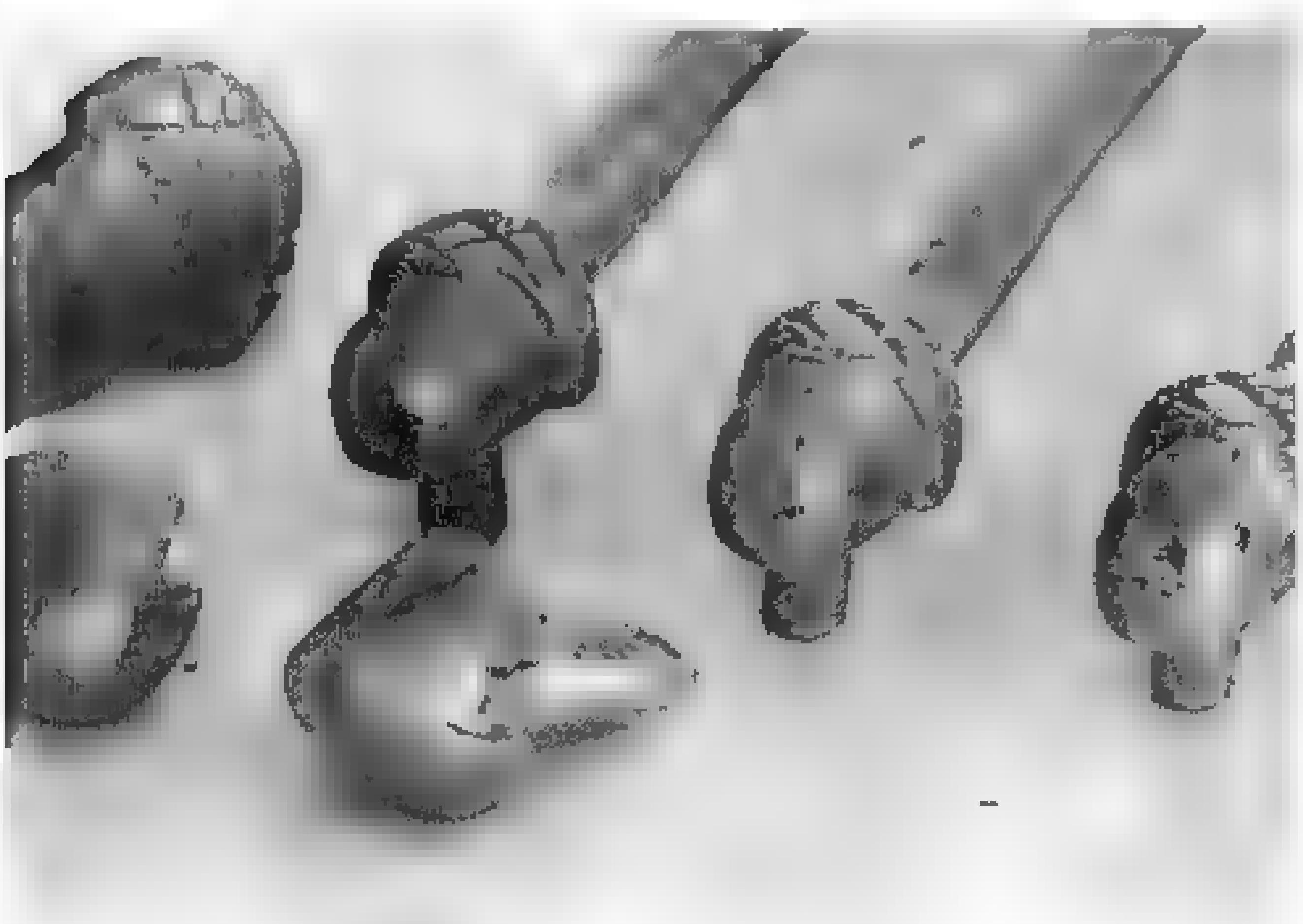


Figure 23.9. These masters, carved by the author in wax, were made into molds and cast in bronze for use on a Bargello-style pair of gauntlets. Note that even the file lines incised into the wax were preserved in the rough casting masters shown here These were applied to the gauntlets shown in Chapter 33

it is brought to a red heat and then quickly immersed in water. Usually this is done with a rosebud tip on an oxyacetylene torch, but the more correct medieval method would be to set a flat sheet of steel on a bed of coals and then place the brass or bronze on top of that, using tongs to remove the trim pieces when red hot and drop them into the quenching bath.

Once the brass has been roughly fit and held in place with small bolts, the final edge of the poleyn can be ground to match perfectly. It is important not to grind the latten border because it should be of equal width at all points. A very light rawhide hammer can be used to gently tap the border against the edge to insure conformity. Be sure to avoid catching excess metal between the rivet points or unsightly buckling can occur.

If the border occurs on an articulation point, as with a poleyn or couter, then the articulation rivet can be used to fasten a portion of the trim, although a small invisible "binding rivet" might be used in the corner to prevent it from being torn loose by a fluke accident.

In the case of a poleyn or couter, the trim is jointed at the wing. This join must be smooth and unbroken such that the lines on the trim resolve neatly and without gapping (fig. 23.7). Pay close attention to detail, as sloppy brass is worse than no trim at all since the eye is drawn to the flashy metal.

Once this is done, a design can be laid using a permanent marker or chalk, recorded, and the trim removed for polishing. Pay particular care to the edges, which should be smooth and without nips or burrs. Only the outside surface need be polished, but it should be done to a mirror gloss using the white compound. Each piece should be marked on the reverse with its placement to prevent mistakes from happening during the etching process. It can either be attached, etched, or engraved according to the instructions below.

Some borders were cast into patterns and applied in small sections at the armour's edge. We have evidence of this from the once-gilded armour of Charles VI, now housed in the Chartes Museum. Each piece of this late 14th century armour was edged with sectioned

strips of gilt border cast into linked fleur-de-lis, a pattern not dissimilar to the edging chosen a hundred years later by Lorenz Helmschmid for his Gothic masterpiece.

If cast borders are done, then the sprue can be cast directly on the back, acting as a rivet. Alternately, holes can be cast through which rivets can be placed for assembly. Sometimes silver can be used for this purpose, though unless the piece is to be covered in rich fabric or blackened it seems an artistic waste, as the silver would be lost against the polished steel.

DECORATIVE RIVET HEADS

During the 14th century, rivet heads were sometimes filed or engraved, usually in designs based on floral work. For

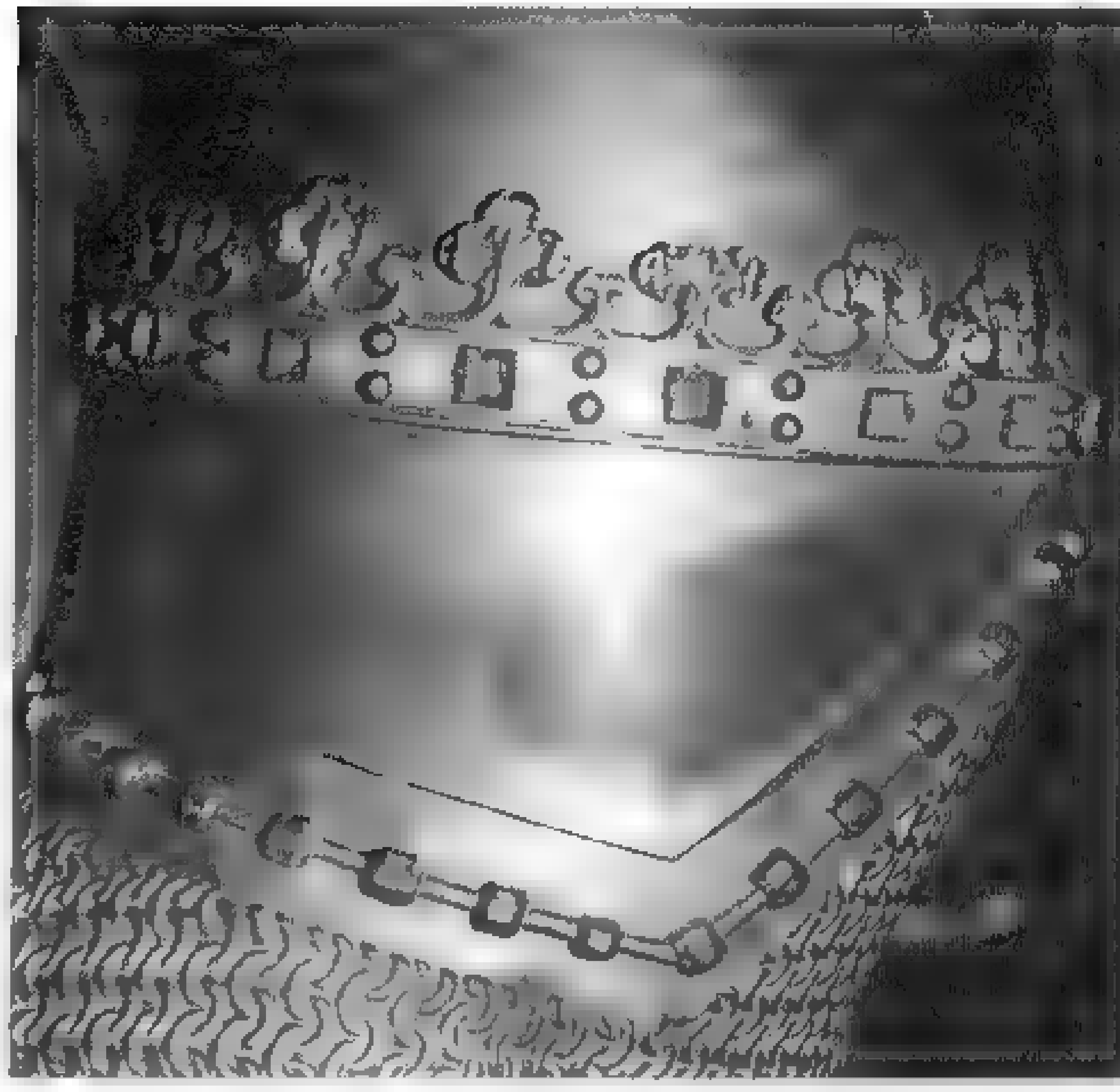


Figure 23.10 Black Prince effigy coronet

Figure 23.11 Reenactment communities sometimes give the armourer the opportunity to enhance his work with jewelling skills. This bascinet will serve in the field as the originals did, to call attention to the combatant's rank and skill. Few helmets feature gemstones as this one does because of the full-contact nature of the martial art it will be used in and the jewels will probably have to be replaced occasionally.

reproduction work, conventional carriage bolts can be easily modified to form a floral bolt by simply marking the head and filing the piece down.

First the bolts—usually common 1/4–20 carriage bolts—are marked with a permanent marker (fig. 23.8). These lines are then filed with a narrow-edged file to make the incised lines. Care must be taken to insure that the lines cross over the center and a bit of extra force is used at the edges (a rounding motion is used to carry over the edge).

Next, round out the areas on either side of the file line and finish the shape with a belt or disk sander, in the process removing any lettering or hardness indicators on the bolt's head. Buffing with a strong compound and finishing with the white compound will complete the look. Sometimes brass bolts can be found, and the same technique can be used on ordinary dome or truss-headed rivets.

Once the heads are complete, the square shank on a carriage bolt must be removed, either in a lathe or with a sander. This is a bit tedious if done without a sander, but it works.

Figure 23.12. Another example of a coronetted bascinet by Charles E. Davis, 1990

CAST BITS

Save for the Chartres border, I have found no direct evidence to indicate that casting was used to any large degree by medieval armourers, and it seems that most brass enhancements during the transitional period were in fact fabricated individually from latten or silver. Nonetheless, there is evidence that buckles were cast during the period, although the lack of remaining examples must leave the question open. Makers of medieval buckles and the like were certainly casting components for leatherwork, and the pieces are markedly similar as those required for brigandine construction or small gauntlet pieces.

Medieval molds were made chiefly from soapstone, the desired shape cut directly into the stone mold, into which the molten metal was then poured. Investment casting—where a wax element was made from a mold, coated in come kind of shell and burned out—has been traced back to Viking and Roman artifacts and could also have been used in the Middle Ages, though I have not researched this thoroughly.

Most modern armourers use the investment method, carving their masters from specially formulated carving wax and then having a rubber mold made from this master. The work can then be sent to a commercial casting house to produce buckles, small rosettes, and decorative trims.

CORONETS

Although virtually no coronets have survived intact, there are numerous literary and iconographic references, especially during the transitional Hundred Years War period. A coronet, when appropriate to the patron, was well-suited to application to the bascinet, since its smooth surfaces could be attached with engraved, etched, or cast materials.

One particularly clear example remains on the effigy of the Black Prince seen in Figure 23.10.[5] This coronet was probably cast, though it could also have been fabricated. It does not show much in the way of sections and is held in place with pairs of rivets that

extend all the way around. Note that the line of the piece appears to be flat but that the coronet must be applied to a surface that is basically conical, a design problem cunningly solved by the placement of the coronet and the narrow neck of the leaves. Notice also that stones appear to have been affixed to the coronet's surface, though there is no indication as to how this was done.

EMBOSSING

While embossing was popular throughout the Middle Ages as applied to leatherwork fittings, it was also popular during the transitional period, especially on gauntlets and for decorative rosettes that sometimes surrounded rivet heads. This practice appears to have remained popular as long as armour was in fashion, though it was largely restricted to decorative rosette washers after the 14th century.

Embossed pieces are generally very thin sections of brass that are squashed in between a hard male master die and either a corresponding female or, more commonly, a piece of lead or wood.

In any embossed piece, the first step is to carve the male master, usually by filing down a piece of hardenable steel. The steel should first be annealed and then quickly formed to shape using stock removal with a sander and files. Next it is hardened.

Soft bronze or steel can be heated with a torch to a red heat while clamped securely in a vice. The hardened male master is then driven sharply into the metal with a heavy steel mallet, making the required impression. The result is then hardened appropriately according to its material. Solid masters will have the benefit of making a crisper pattern, though they are harder to produce. (In Chapter 33, the bracelets on hourglass gauntlets are made in this fashion.)

Without going to all the work, a steel master can be used effectively with a lead block to produce a number of pieces in a short amount of time, although the lead block will tend to deteriorate under the pressure of the stroke and must be renewed from time to time. Gauntlet gatlings are commonly done in this fashion, where a master is made and pounded into a lead block to yield the approximate shape, and then these small pieces are finished as usual (fig. 23.13).

Rosettes or decorative washers have been produced in this manner since Ancient Rome. (Remnants of recovered Roman *lorica segmentata* armour feature brass rosette washers very similar to those used in the late 15th and

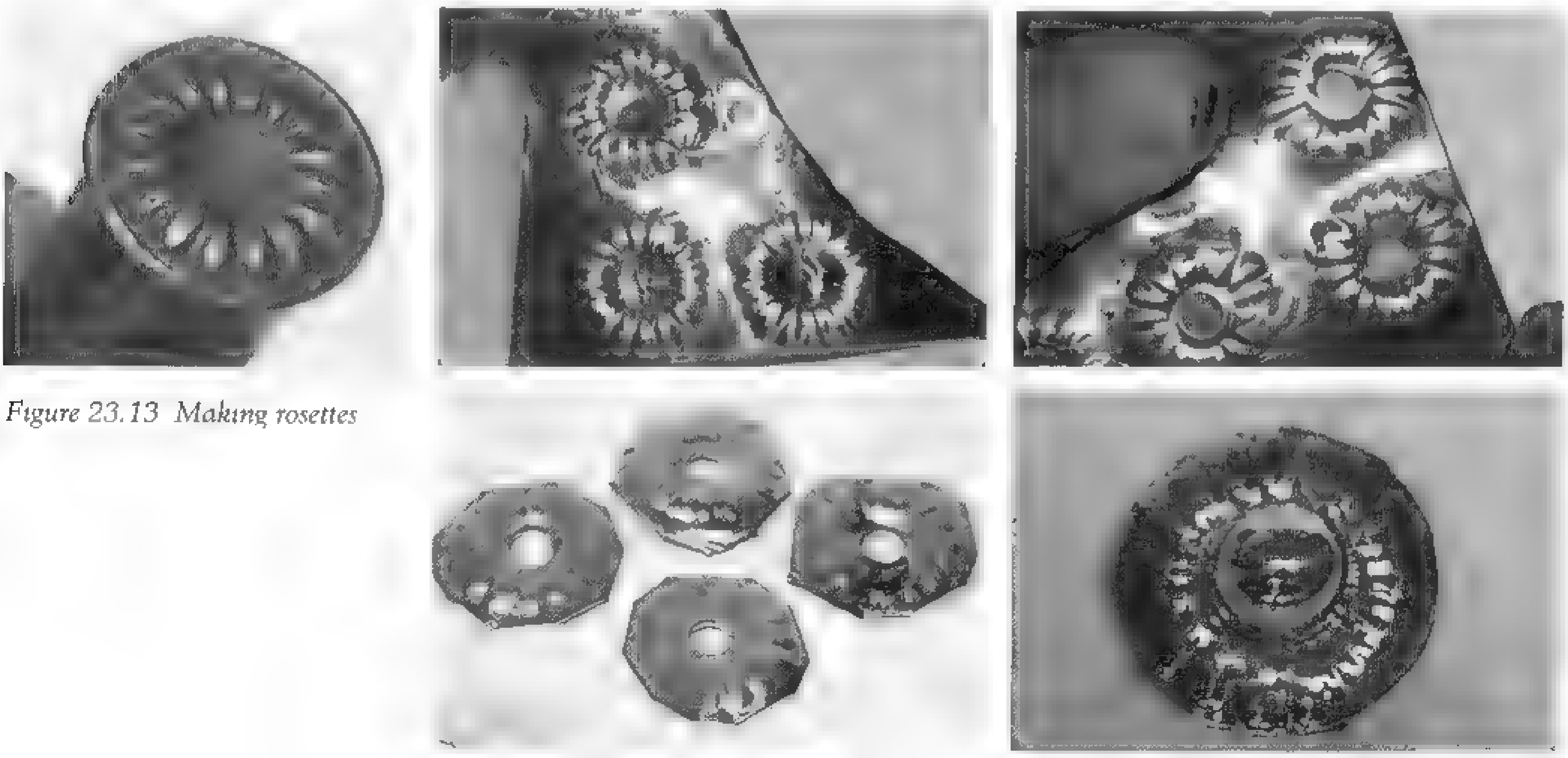


Figure 23.13 Making rosettes

16th centuries.) After the rosettes are punched into the lead, the edges are trimmed and the central hole punched out, yielding a completed decorative washer with minimal cost.

ENGRAVING

Engraving—the primary technique used to add texture, lettering, and design to armour in the 14th and 15th centuries—is an advanced skill somewhat beyond the scope of the novice/intermediate focus of this book, though the basic theory will be instructive for determining future direction.

Specialized tools of very hard (and brittle) steel, appropriately called gravers, are set into a wooden handle. Sharpened and held rigidly against a well-clamped work surface, the graver is moved against the metal, digging a thin sliver out of the surface and creating a very clean, crisp line of engraving. As hinted at above, simple geometric shapes and lettering seems to have formed the majority of engraved décor in medieval armour (fig. 23.15), though some floral work is also evident.

Modern gravers are probably little different from their medieval counterparts, although some armourers have opted to use special attachments to a flexible-shaft tool or a Gravemeister to speed the process and reduce the tedious skills required.

Figure 23.14 Gravers can be purchased inexpensively from most major jewelry tool supply houses. Engraving is not for the novice (an ability to draw helps immensely), but it is the most correct method of inscribing designs on borders. The quality of the cutting edge is of paramount importance with engraving, so a high-quality stone is as important as the graving tools themselves

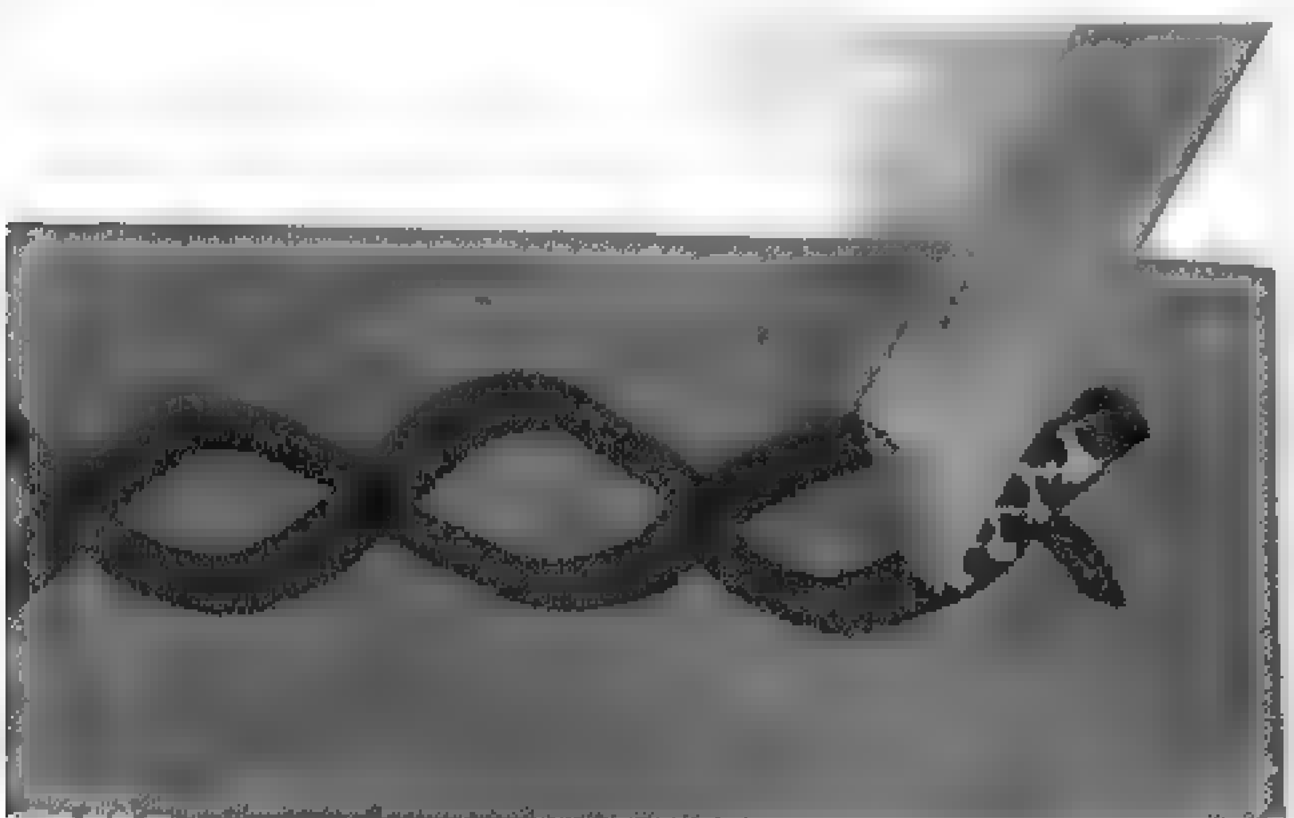


Figure 23.15 Most surviving trim is decorated with engraved rather than etched patterns, usually simple geometric designs. So-called "wigglework" always adds appropriate texture to a piece's latten trim. The graver is simply walked from side to side I sometimes prefer to add a line of permanent marker to guide the work as shown above, but with practice this is unnecessary

ETCHING

While engraving removes small slivers of metal from the work surface with a sharp mechanical point, jewelers during the 13th and 14th centuries also used baths of acid (called *Aqua Regia*) to create a chemical reaction that would remove material.

In the etching process, a "ground" or asphaltum (also known as "resist"), usually composed of wax and varnish, is applied liberally to the work area. The asphaltum, which protects the metal's surface from the acid, is then carefully scraped away from all the areas the artist wants recessed. Once dipped into a bath of acid and water, a chemical reaction between the metal and acid results in a finely cut décor.

The etching process is easy to master, even for the intermediate, but it is potentially dangerous and the acid should be treated with appropriate care. Most period recipes call for nitric or sulpheric acids, and in sufficient strength to cut metal they are not only dangerous to most materials—and to the body—but the reaction causes the release of highly toxic gasses, so this should not be done

without extremely good ventilation and not at all by those with respiratory problems or who are pregnant.

Etching a Brass Border

Medieval jewelers were familiar with a variety of acids, although they were not well distinguished in their texts. Nowadays nitric acid is the most commonly used, and it can be purchased from laboratory or chemical supply houses. Although different jewelers have recommended different kinds of acid, I have always liked the flexibility and precision available with nitric, which in different strengths can etch steel, brass, or bronze with equal quality. The armourer will also require resist, which can be purchased from better art supply houses, where it is sold to artists and students working on etched plates for printing.

The first step will be to coat the pieces with resist, using a leather dye "dauber" or soft brush. Be sure to degrease the metal first or the resist may flake off, either when the design is being applied or, worse, when it is in the acid bath. Use care not to put brush-stroke lines into the work or these will also etch. The asphaltum can be applied afterward to cover mistakes, a convenient solution to difficulty with the drawing.

Do not put the asphaltum on too thickly or it will be difficult to remove with precision. The coating should be completely opaque, but not more than 1/32 inch or so thick. Allow it to dry for 8 to 24 hours before working further. Once the resist has dried (fig. 23.17), it is time to transfer the pattern to the piece and gently scribe away the asphaltum (fig. 23.18).

I usually first draw the design onto a piece of paper and then lightly trace it directly onto the asphaltum, which has the effect of transferring a very faint line onto the resist. An ordinary pencil works well for the roughing stage, since it removes just enough resist without peeling to be useful. Sometimes this is enough to remove the resist, but in other cases a scribe or pencil eraser must be applied to remove the very faint resist that remains. If the surface of the metal does not come through as shiny, then some resist still remains and the acid will not cut well.

For detailed sections such as lettering, I use the scribe first to define the edges of the lettering and the pencil to remove the larger sections of resist in between. For very large areas, go over the area with an eraser to remove small streaks of resist left by the pencil or scribe.

Generally speaking, it is a good idea to prepare a stack of pieces before readying the acid bath, since the bath is inconvenient to set up. Before the bath is set up, the artist should prepare the worksite by making sure there are no combustibles in the immediate area; that there is a legal and appropriate method for dealing with the acid (either EPA-approved disposal methods or storage); and that rubber gloves, goggles, a large container of water, and baking soda is available (the last is to counteract the acid in the event of spills and to neutralize it when the etching is complete). A brush or quill will also be useful for wiping the bubbles from the surface. Plastic tongs are excellent for removing items from the acid bath.

For most operations, a 1:3 or 1:2 mixture of nitric acid and water will be sufficient, with water being the dominant element. *Always add acid to water*, not the other way around (fig. 23.19). Adding water to acid results in dangerous splattering that will splash concentrated acid all over the workspace. Start with a weaker concentration of acid at first, since more acid can always be added as necessary. Use

Figure 23.16. A bottle of nitric acid.

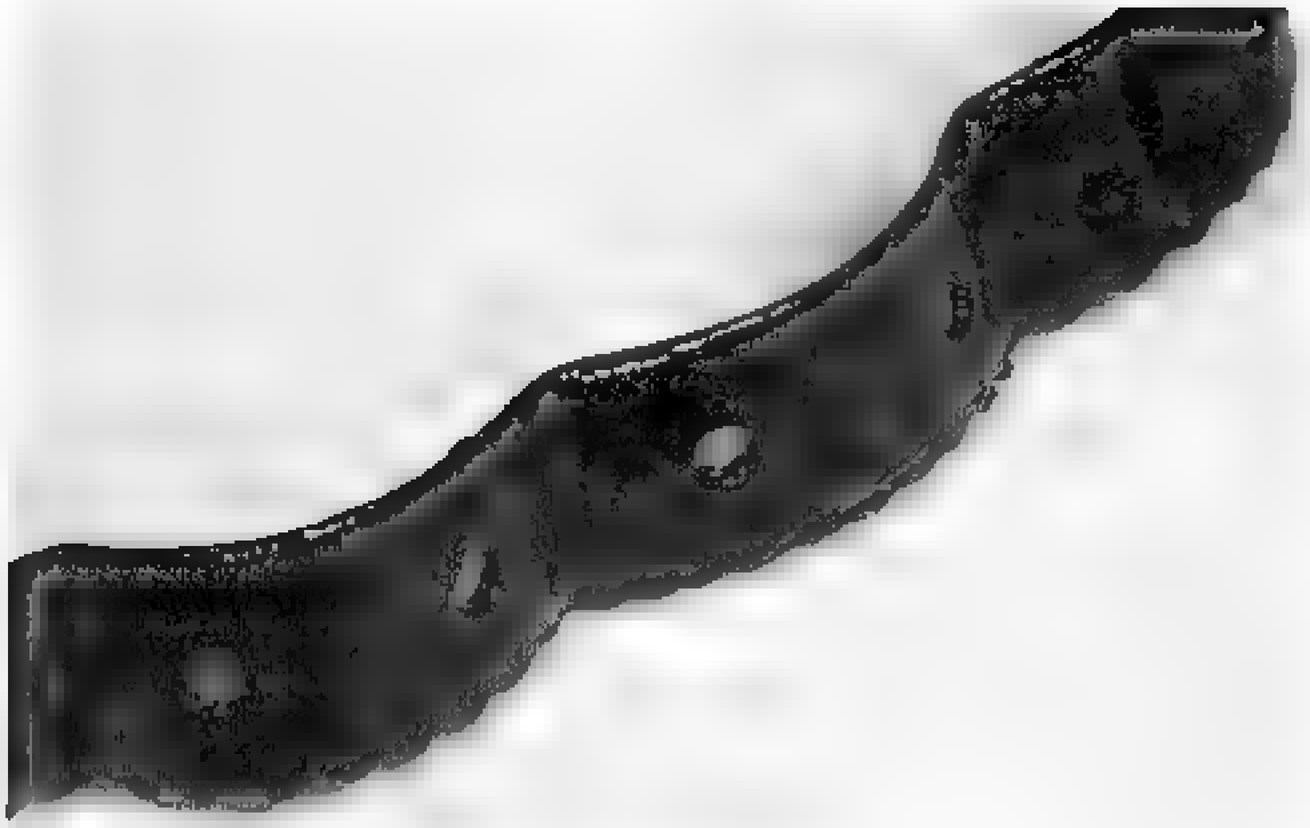


Figure 23.17. This piece of brass trim for a gauntlet piece has been coated with resist after it was fit to the gauntlet metacarpal and finished. The quality of the surface treatment is important because it will determine how easy the resist is to remove with a stylus or pencil. Note that the resist is opaque but not applied very thickly. Ideally, the holes would also be coated with resist to reduce the chances of chipping in this critical area.

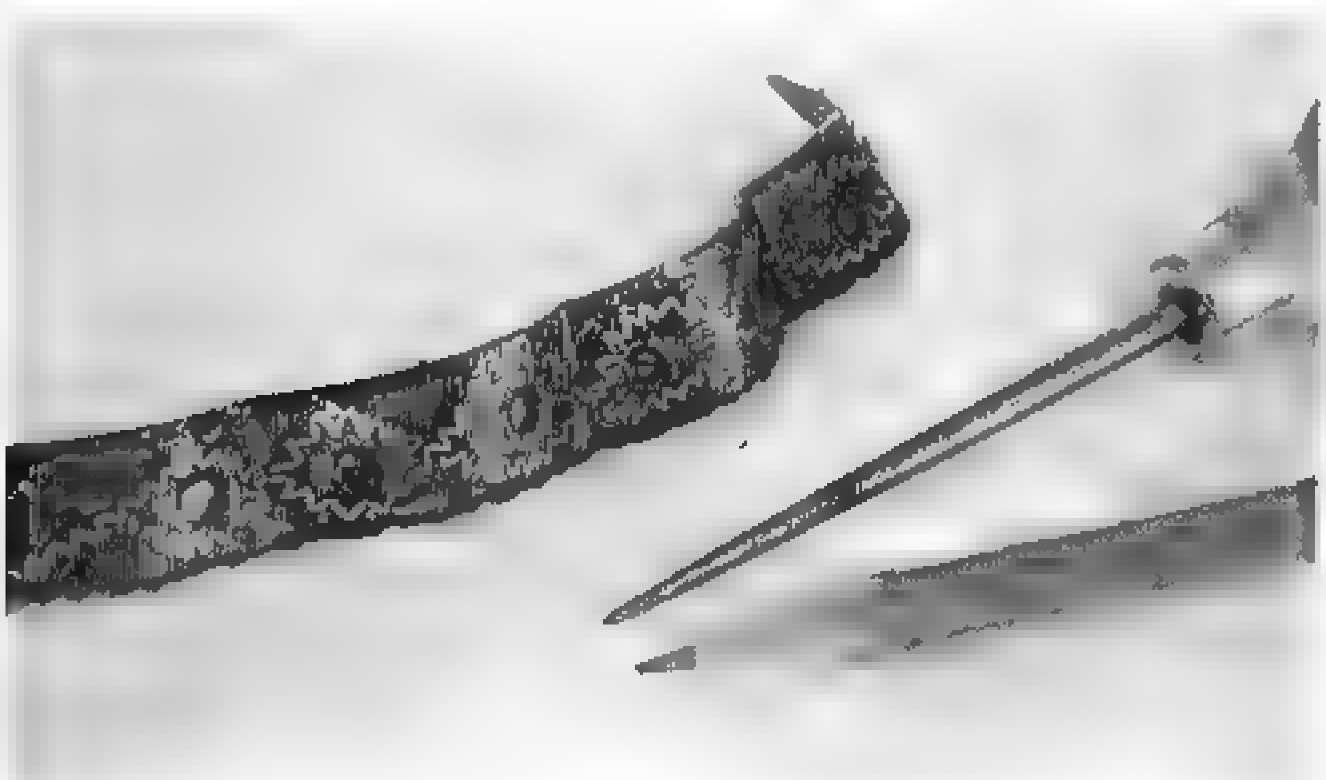


Figure 23.18. Removing the resist.

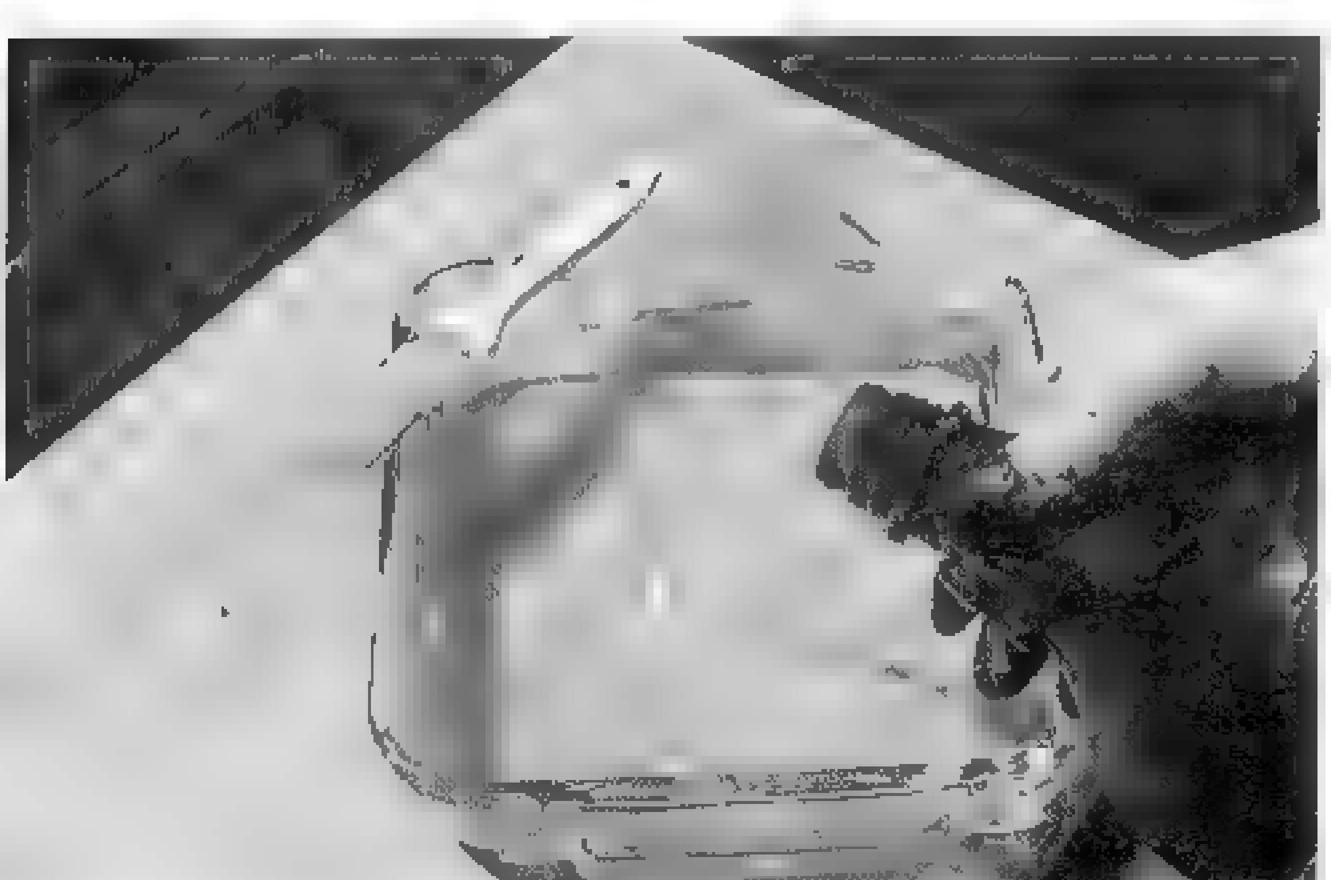


Figure 23.19. Always add acid to water, not the other way around!

something like the 1:3 ratio for nonferrous metals such as brass and 1:2 for more resistant metals such as steel. Do not attempt to conduct etching in wooden or metal containers, as the acid will eat the container. The use of laboratory glass is preferable, but ordinary baking dishes will work (just don't plan on using them for food afterward).

In some instances, I have done the etching on an inexpensive hot plate to increase the pace of the reaction. I don't recommend this for the novice, but it is especially useful on large pieces of steel.

Now comes the moment of truth. Immerse the piece into the bath. Bubbles should form within a few seconds on all areas of exposed metal and begin to release into the atmosphere above the bath (fig. 23.20). Remember that these gasses are toxic and should not be breathed. If the bubbles aren't releasing from the metal's surface or if there are no bubbles at all after a minute or so, then it is likely that the bath either isn't strong enough or it's too cold for the reaction to occur. Note that like all chemical reactions, the reaction itself will act as a catalyst to further reactions, so in an etching session the later pieces will etch much faster than the earlier ones. The bath will also warm with the reaction, further speeding the etching.

From time to time the bubbles should be removed either by lifting the piece from the bath (which is a good way to inspect it to insure that resist is not peeling off) or by brushing with a soft brush or quill. Anything taken out of the acid bath should immediately be dipped into water to wash the acid from the surface. A piece that is not yet finished can be placed back into the bath or it can be washed gently and recoated with resist in the unfortunate event of the resist cracking off.

The etching will progress until the work is removed from the bath or until the acid burns itself out (though it is more likely your piece will cease to exist as a solid before that happens). When you can see bubbles clinging to the newly cut edge of the material, the etching is complete and should be placed into the wash for a few minutes before removing the resist.

After the piece has sat in the wash for a few minutes, the resist can be removed. Ordinary gasoline works well for this, but remember that gas will eat rubber gloves, so they should be removed first. Soak the piece in gasoline for a couple of minutes and then use a clean, dry, and disposable cloth to clean the remainder. This step is messy but easy and fast (fig. 23.21).

At this point the acid must be disposed of or stored in a glass container for future use. Use extreme caution when storing acid, as it is a major fire hazard, not to mention the damage that could be caused should a bottle fall and shatter. To dispose of unwanted acid, neutralize it by diluting it in a large bucket of water and heaping large amounts of a basic material such as baking soda. The remaining material should be disposed of according to your local environmental laws.

The final pieces are now ready to attach back to their component parts once they have been polished. Pay particular attention to the edges. Also, the black waxy residue that is left by the white buffing compound will darken the etched areas slightly, causing them to stand out better. Note that brass and bronze pieces attached to the armour will not only tarnish quickly (less so if coated with a protective agent such as Renaissance wax) but will cause an electrical reaction that speeds oxidation of both metals. This effect can be reduced by coating the back of the brass pieces with brushed-on enamel paint.

One alternative method that is popular with reenactors is photoetching, a process by which the image is transferred to the metal from an artwork master, which drastically reduces the time required to produce each piece. Commercial houses specializing in this work produce whole sheets of uncut patterned material, leaving the armourer to cut and file them to shape, anneal them, and attach them

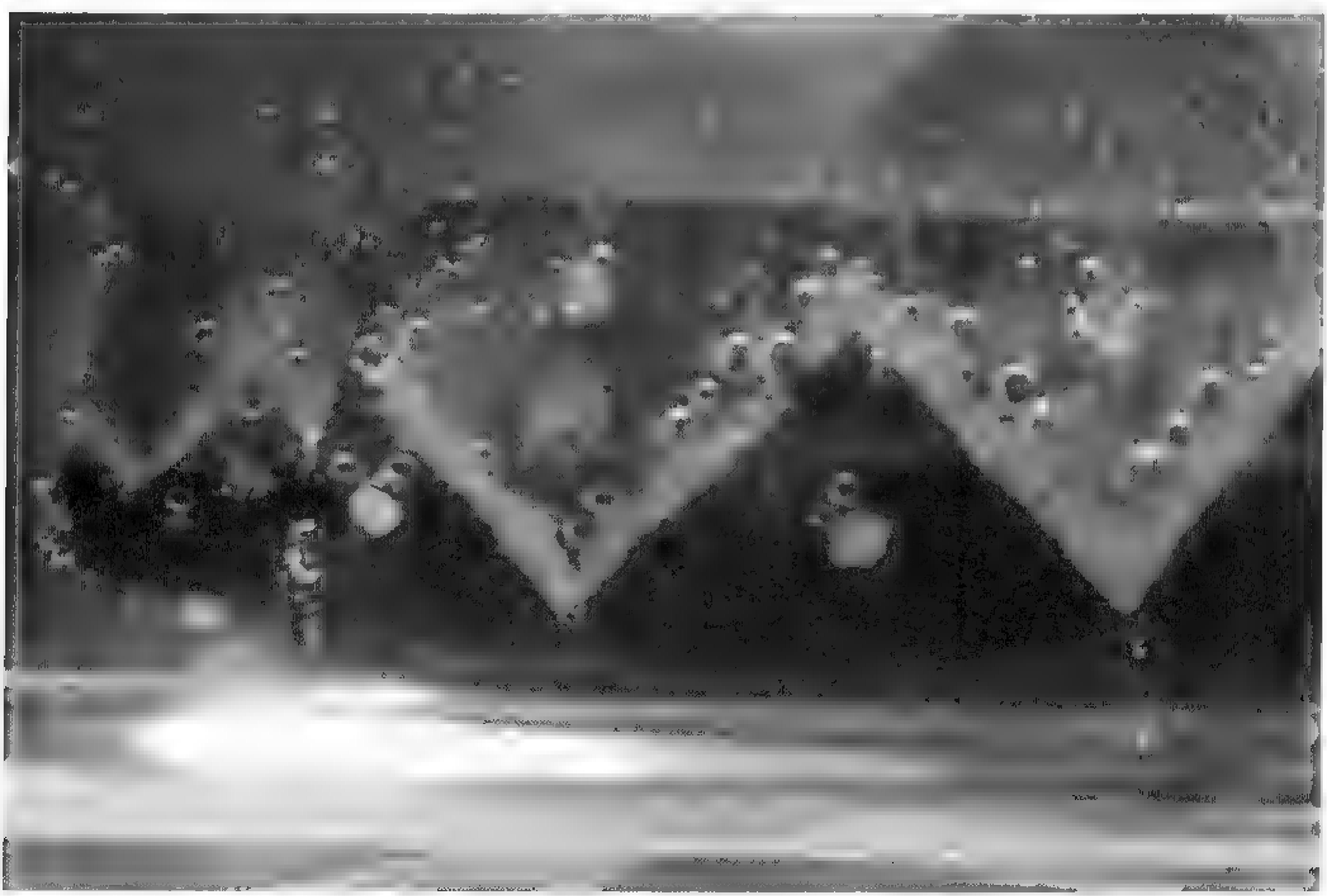


Figure 23.20. Immersing in the bath

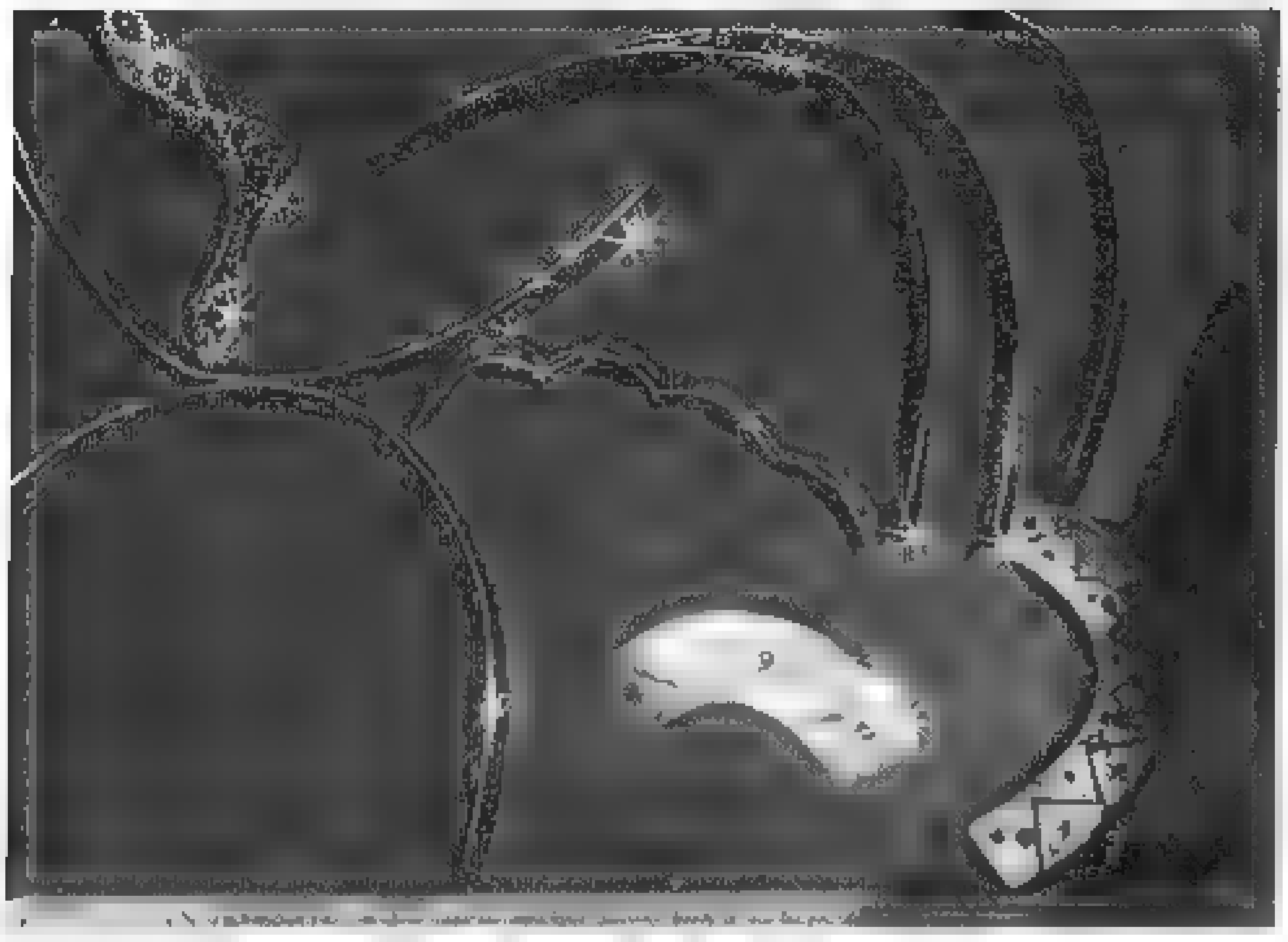


Figure 23.21. After the resist has been removed.

Figure 23.22. Before final polishing.

Figure 23.23. Cuff detail showing letters.

to the workpiece without resorting to the acid treatment. The results are precise, if a bit costly, and the armourer must be willing to wait the week or more required to get the pieces back from the etching house.

FABRIC COVERING

I will not go into great deal on techniques of covering armour in fabric, but the idea was popular—especially in Italy—throughout the 14th and 15th centuries. High-quality velvets and brocades were used for this purpose, and it is likely that some of the extraordinary brass trim that remains was used to hold such fabric in place.

Decorative rosettes of iron and brass were also used to hold fabric in place, as can be seen both on funerary effigies and on the covered breastplate now in the Bayerisches Nationalmuseum, Munich. Covering in fabric gave the armourer the opportunity to finish the metalwork phases more quickly, though the time needed to add fabric is just about the same as it is to finish the metal with a white polish, although the work is easier to accomplish and very easy to maintain when complete.

CHASING AND REPOUSSÉ

Really an extension of basic embossing skills, chasing and repoussé work (the art of using tools to create a design in metal by working it into lead or pitch) pushes relatively thin metal around such that it is truly sculpture. While strongly modeled surfaces existed during the 14th century, it is likely that these defenses were of leather rather than iron, steel, or latten since there is no corroborating evidence to support such work in this period.

In the 16th century, however, three great families pushed the armourer's art onto the territory of the sculptor. In Italy, the Negroli family produced work that has accumulated in royal armouries throughout Europe for its quality and artistic merit. In Germany, the Susenhofer family produced equally accomplished work with figures both grotesque and beautiful, and the Peffenhausers started a

How to Gild[6]

Benvenuto Cellini
c. 1568

"When you want to gild you take the purest, 24-carat gold & beat it out with clean hammers on an anvil until you get it to the thinness of a sheet of writing paper. Then you cut up as much as you want into small pieces. After this you take a new crucible never yet used & such as goldsmiths melt silver and gold in, and into it you put as much quicksilver,[7] free from all impurities, as maybe needed for the gold you want to employ. The proportion is at the rate of one ounce to a scudi's weight, that is to say, one part gold to eight parts of quicksilver, rather less than more of the latter. Note that you should first mix together the quicksilver and gold in a clean vessel of earth or wood, and you put the crucible on a fire of glowing embers, but not using the bellows. When the crucible is red you throw it into some of the mixed quicksilver and gold, hold it over the fire, and with a glowing ember gripped in a pair of tongs stir it thoroughly together.

Your eye & the feel of your hand will tell you whether the gold is dissolved and united with the quicksilver. Great care has to be taken to aid the solution by rapid stirring, for if you hold it too long, the gold, or rather the amalgam will get too thick; if, on the other hand, you hold it on too short a time, it will be too thin, and the gold not well mixed. The great care which this requires can only be got by practice.

When it is all mixed & dissolved, & everything done in the manner described, you take the hot mixture & pour it into a beaker or vase in accord with the amount of gold you have mixed, and this vase is filled with water, so that you hear it hissing when you pour the mixture in. Then you wash it thus two or three times in clean water, till finally your water is quite clean and pure, and then you set about the actual gilding as follows.

Wherever you want to gild on your work you have to get it well polished and scratch-brushed—*Grattapurgiata*—for so it is called in the craft. These scratches are made of brass wire about as thick as a thread & done up into bundles as thick as a man's finger, more or less, in accordance with the size of the work you want to scrub, & tie around with brass or copper wire. Of course you can buy these brushes at a grocer's, but there they are usually sold only in one size; so that your skilled workman if he wants to do his work well, and has a large piece to do, binds up his own brushes according to the size he wants.

After the scrubbing, you put the amalgam on with an *avvivatoio*, for so we call the little rod of copper set in a wooden handle, & much the same size and length as a table fork; here, again, the size accords with the requirements for your work. Carefully then do you proceed to spread the amalgam over the places you want to gild. True it is that some have put quicksilver on first, then spread the amalgam on after, but this is not a good method, for too much mercury dulls the color and beauty of the gold. Others, again, have throught to do better by putting the gold on in successive times. This I have likewise seen done, but have come to the conclusion that the best way is to put the gold on all at once, that you want for your gilding, and then heat it over a slow fire, till all the quicksilver goes off in fumes.[8]

If you notice that the gold on your work is not even, you can, while it is still warm, very easily add on as much as may make it so, till all is covered with gold. Then let it cool by itself. I forgot to say in its proper place that if the gold won't stick on you will do well to have a little whitening water—*bianchimento*—of which I told you above, and you dip your *avvivitoio* with the gold in this water, & if that still won't help you, take a little aquafortis (acid) evaporated and weakened, and there's no doubt this will do it."

tradition of covering a piece of armour with hundreds of intricate figures. The pieces were often gilded and blackened, though this work was used mostly for parade and is sadly beyond the scope of this book.[9]

GILDING

Two techniques of gilding seem to have been used during the Middle Ages and Rensaissance to bond gold to steel. The first was the traditional application of gold leaf, although I have not been able to discover the bonding agent used to fix the gold to the steel. The second method is recorded in several 16th century sources, although it is likely that the gold-washed pieces of the 14th and 15th centuries were done using the same technique.

Essentially, gold was mixed with mercury, melted into an amalgum, and painted on metal already prepared by brushing the surfaces to be coated with brass brushes. The metal was then heated (the process is also known as "fire gilding") and the mercury burned off in a highly toxic vapor, leaving the gold bonded to the metal. This process was often combined with the final tempering and could be combined with blacking or bluing to achieve striking black and gold effects popular on high-end armour produced from the middle of the 16th century onward.

Modern plating techniques use electricity to bond the gold to the metal, but the result is a much thinner layer of gold that doesn't have the same texture as the fire-gilded originals. I have never found a plating workshop willing or capable of working with mercury gilding techniques, especially since a modern hood and scrubber would be required in the heating area.

ENDNOTES

1 See the Black Sallet in the Royal Armouries or the Topfhelm in the Nurnburg Germanisches Nationalmuseum.
2 The gauntlets of the Black Prince, now in Canterbury Cathedral, are of gilt latten. It is not known whether these were worn before his funeral, however, and so could be simple funerary achievements without being intended for use.
3 The anachronistic hourglass gauntlets worn by combatants in Uccello's *Rout of San Romano* might be representative of this trend. In a day when distinctive three-piece mitten gauntlets were the normal fashion, the combatants on each of the three panels are pictured with hourglass gauntlets more appropriate to 1370–1400 than to the middle 15th century
4 For the most part the cuisse top edge is covered on funerary effigies, but this seems logical
5 Another fine example of a coronet's corroded imprint on a helmet exists in Poland, but I have been unable to secure permission for reproduction in this volume That coronet is very large—perhaps 4 inches in height, and would have been constructed from a thinner engraved material (or maybe even leather) rather than a large, heavy cast piece
6 *The Treatises of Benvenuto Cellini on Goldsmithing and Sculpture*, Dover edition, Trans. by C R. Ashbee, 1967, Chapter XXVI, pp. 96–97
7 Mercury.
8 Once again, I must stress that this would produce a *highly* toxic mercury vapor and must not be attempted without proper controls by commercial-grade scrubbing equipment
9 Pyhrr, Stuart W., and José-A. Godoy *Heroic Armour of the Italian Renaissance*

Chapter

Strapping and Leatherwork

Although most armourers don't delve very far into the leather worker's craft, they must be able to do enough to strap their armour correctly once it is complete. Unfortunately, sometimes good pieces are ruined in their presentation when incorrect or poorly executed strapping is added. With just a little bit of care, a few techniques, and a trick or two, any armour can be nicely backed, strapped, and readied for use.

A combatant's field appearance is greatly enhanced by the details done in the strapping phase. Straps colored to match the heraldic presentation can go a long way to making a rough-and-tumble appearance coherent. Likewise, the addition of medieval-style buckles and rivets is another often overlooked detail that can improve the overall quality of the presentation.

SELECTING THE LEATHER

The first task is to select leather appropriate to the project. Leather is sold by weight, usually the number of ounces present in a square foot of the material. It is also generally graded according to the quality of the hide, the dye job, and the location of any brands. "A" quality is the best, while "C" quality is the economy version of the hide.

Opposite page
Figure 24.1 Buckles commonly used to strap armour

The armourer will want to use leather primarily for two purposes: to line the backs of pieces or to make strapping. For lining, very thin 3–4 ounce leather can be used. This material is slightly thicker than what is used for bookbinding and is usually available in a variety of appropriately heraldic colors. Strapping leather should be thicker; generally 5–6 ounce should be considered minimum, though I tend to prefer something in the 7–8 ounce range.

Leather is of course an organic material, so the properties vary according to the animal it was taken from. Pig or cow leather is generally most appropriate.

For strapping, I have used two materials with good success. First, "latigo" leathers tend to be nicely finished and are sometimes even available as cut strap. Second, undyed vegetable or oak-tanned carving leathers are excellent for straps, though the armourer should pull on it to insure that it is dense enough and will not tear readily.

Leather is generally purchased by the hide or shoulder and is charged by the square foot. At 1999 prices, expect to pay between $2.50 and $5.50 per foot depending upon the quality of your purchase. Some latigos might even exceed this price, but the investment is often worth it on reenactment pieces, as a great deal of stress is put on the straps under combat and the latigo possesses superior strength.

While leather is available from various craft stores and some specialty leather craft outlets, it is generally very expensive to purchase this way. A better method is to try and find a leather source used regionally by clothing and saddlery makers. There are four or five of these in California alone (some are listed in Appendix C).

DYES AND FINISH

Dyes and finishing materials are usually available from these same supply sources or from local cobblers. I have found the best luck with the Lincoln or Fiebings brands, although others will work as well. The jars of dye usually come with a single dauber. The armourer will want a number of these daubers for leather projects, although ordinary sponges work just as well.

In addition, there are various treatments available to prepare leather for dying and for sealing the surface after the dye is dry. I don't know how authentic any of these treatments are; I generally use wax to seal the leather I dye, usually paste or Renaissance wax buffed gently into the surface.

HARDWARE

The armourer will also need buckles, thread, and rivets for strapping and leatherwork. While these too can be purchased from suppliers (check with your local leather supply house for good sources), authentic buckles can be fabricated by the armourer for special projects (see Chapter

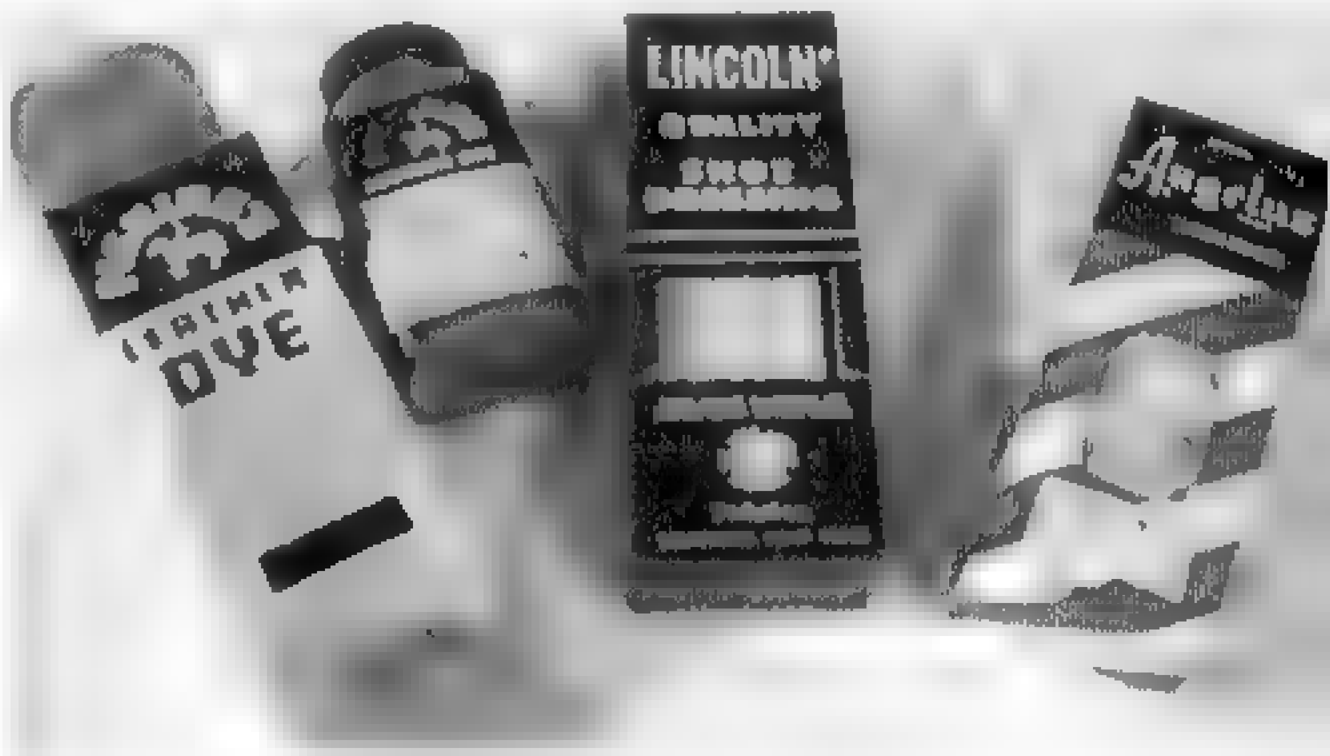


Figure 24.2. Dye and treatments are available either locally from cobblers or through the mail from large leather supply houses

Figure 24.3. Leather rivets can be made from ordinary round or truss-headed rivets or, less authentically, from two-piece "speed" rivets

24). Medieval-style buckles were often cast, and replicas of them are sometimes available from armourers or jewelers specializing in medieval equipment. See Appendix C for some specific sources.

The common two-piece "pop" rivet is convenient for use on lower-level reproductions. They are inexpensive and very easy to set. Just take the two pieces and hammer them lightly on a flat surface.

For more authentic pieces, truss-headed rivets can be used with a backing washer. These rivets can either be placed over a decorative washer or can themselves be filed into floral shapes.

Alternatively, straps can be held in place with waxed linen thread, something which provides for exceptionally fast field repair in the event of failure and which does not require special tools. The thread is commonly available from weaving or some leather suppliers.

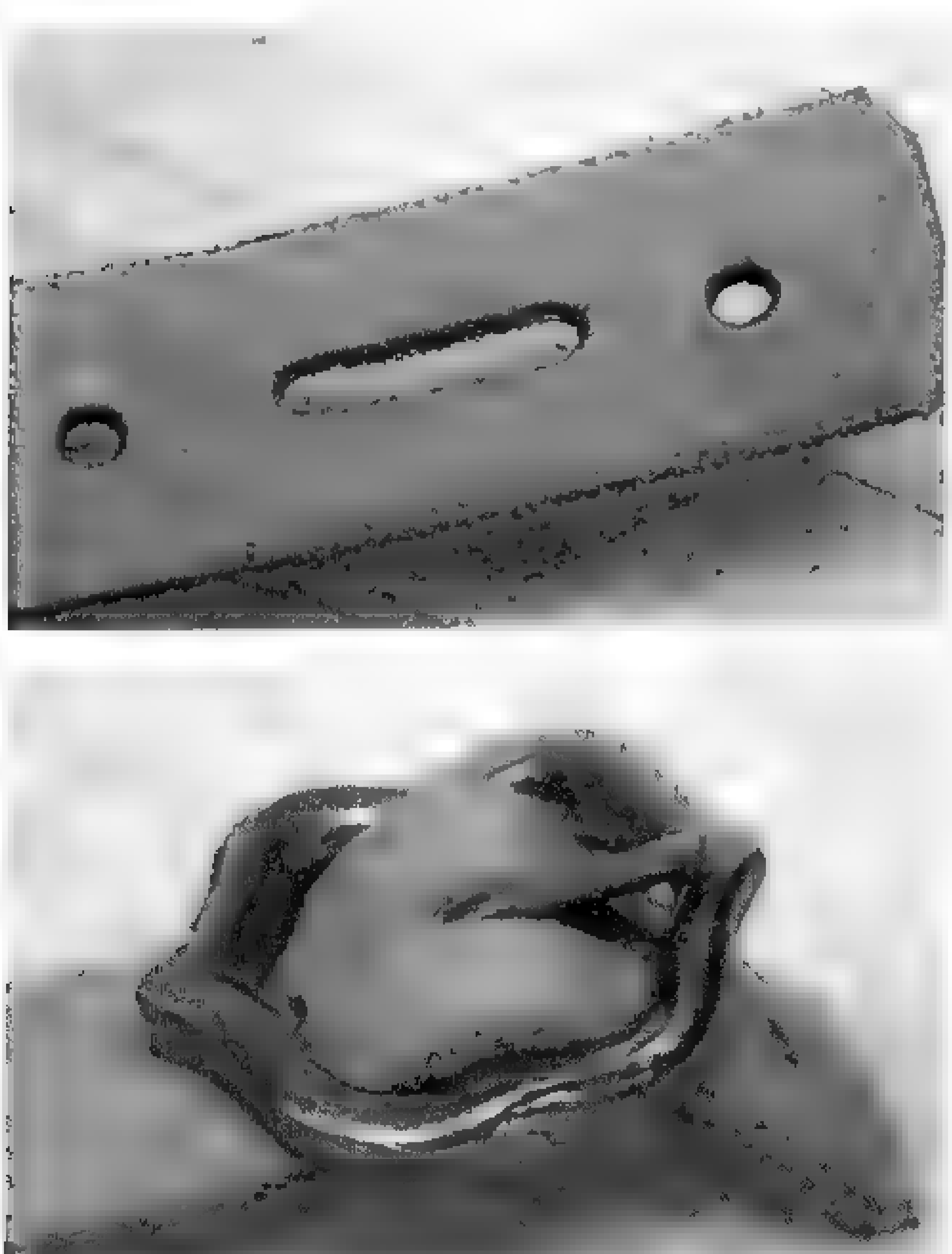


Figure 24.4. Assembling a buckle

Aside from these things, only a few tools are required for strapping: a box knife, straight edge, hammer, and rotary punch are the minimum, though edgers, strap cutters, single-hole punches, oval punches, strap-tip cutters, and leather scissors will make the work easier. Large needles will be needed if the waxed linen thread is used.

BASIC STRAPPING

There are two main kinds of buckles: O or D shaped and Figure 8 shaped. Both seem to have been used throughout the 14th and 15th centuries, although the appropriate shapes changed slightly though the years.

A buckle requires two straps. The first is the "female" strap, which features an oval-punched hole flanked by two rivet holes (fig. 24.4). The oval will be used for the buckle's tongue. This piece of leather is folded in half around the buckle and the rivet set on the far side. Once done, another hole is placed in the strap to attach it to the armoured plate.

The second strap is a "male" strap. This one is simply a strip with the tip cut to a point (either in a reversed escutcheon shape or simply trimmed to a triangular point). Sometimes the tip is left square, and sometimes a piece of steel or brass is set over the edge. Holes are then punched in the male strap and it is attached to the armour.

Strapping should be cut out of a minimum of 5–6 ounce leather, although the appropriate weight will depend to some degree on the piece in question. Gauntlets and spaulder straps can be lighter, as can those on a gorget, because very little stress is put on them. Straps securing the legharness, cuirass, or helmet should be made of stouter stuff.

If using a knife, the leather is laid flat on a sheet of soft wood, cardboard, or plastic (fig. 24.5). Using care not to lose control of the knife, a straight edge is placed alongside the line you want to cut and the knife gently drawn down its length. Sometimes multiple cuts are required. The straight edge must be held firmly or the leather will creep and the width of the strap will vary.

An alternate method is to use a commercial strap cutter. This method nearly insures perfectly cut straps because a stop is used to maintain the strap's width through the cut. Some combatants purchase precut strips, though this tends to be an expensive option. I carry precut strap widths in a small repair kit when I fight, some already fitted with buckles of the appropriate size.

On the male buckle, the tip should be cut if an escutcheon or triangular tip is desired (fig. 24.6). For square tips nothing need be done at this point. Any square corners are trimmed for neatness.

Once the strap is cut, the edges should be trimmed with a commercial edge trimmer (fig. 24.7). The trimmer is simply run along the leather's edge at a 45 degree angle, removing a narrow piece and leaving a nicely beveled edge.

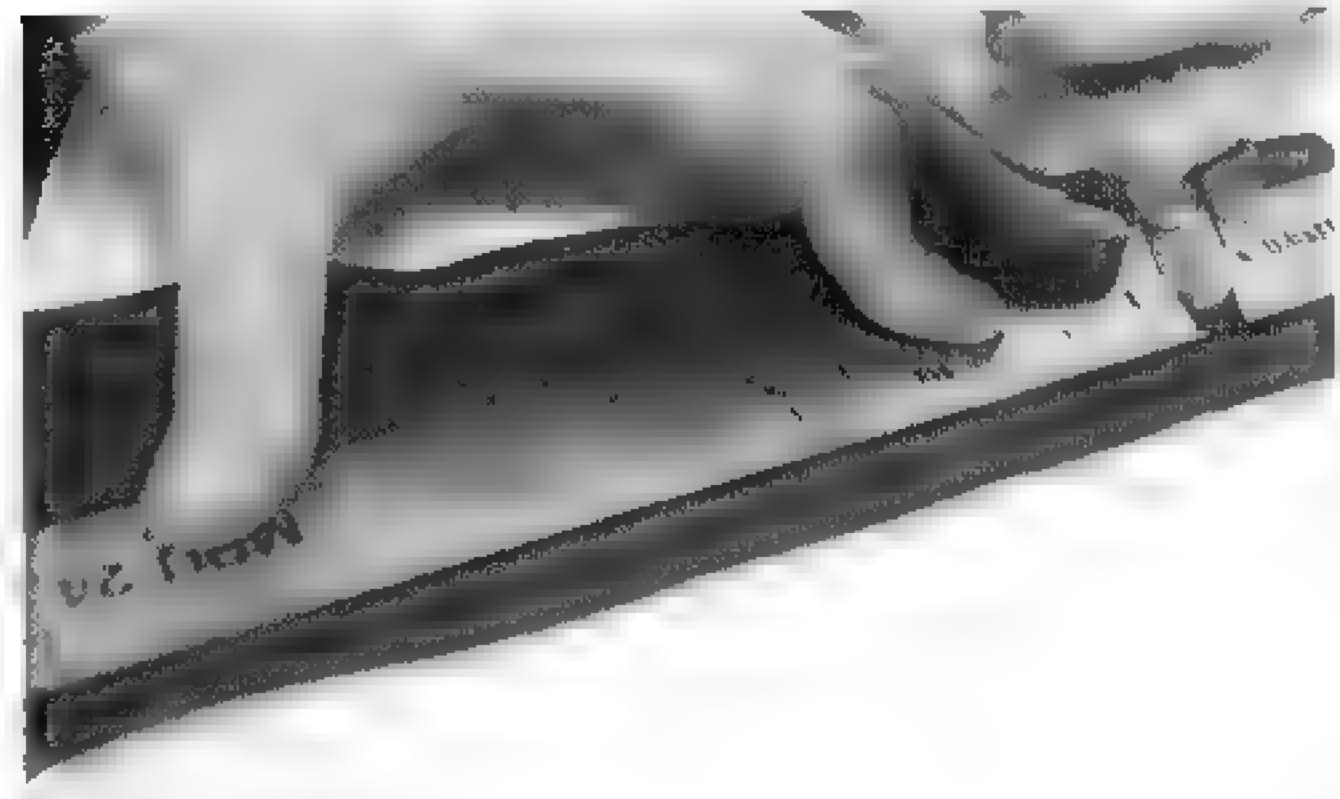


Figure 24.5. Care must be exercised when cutting a strap with a box knife so that the knife does not slip and cut the user and the straight-edge doesn't slip to produce a wavy strap

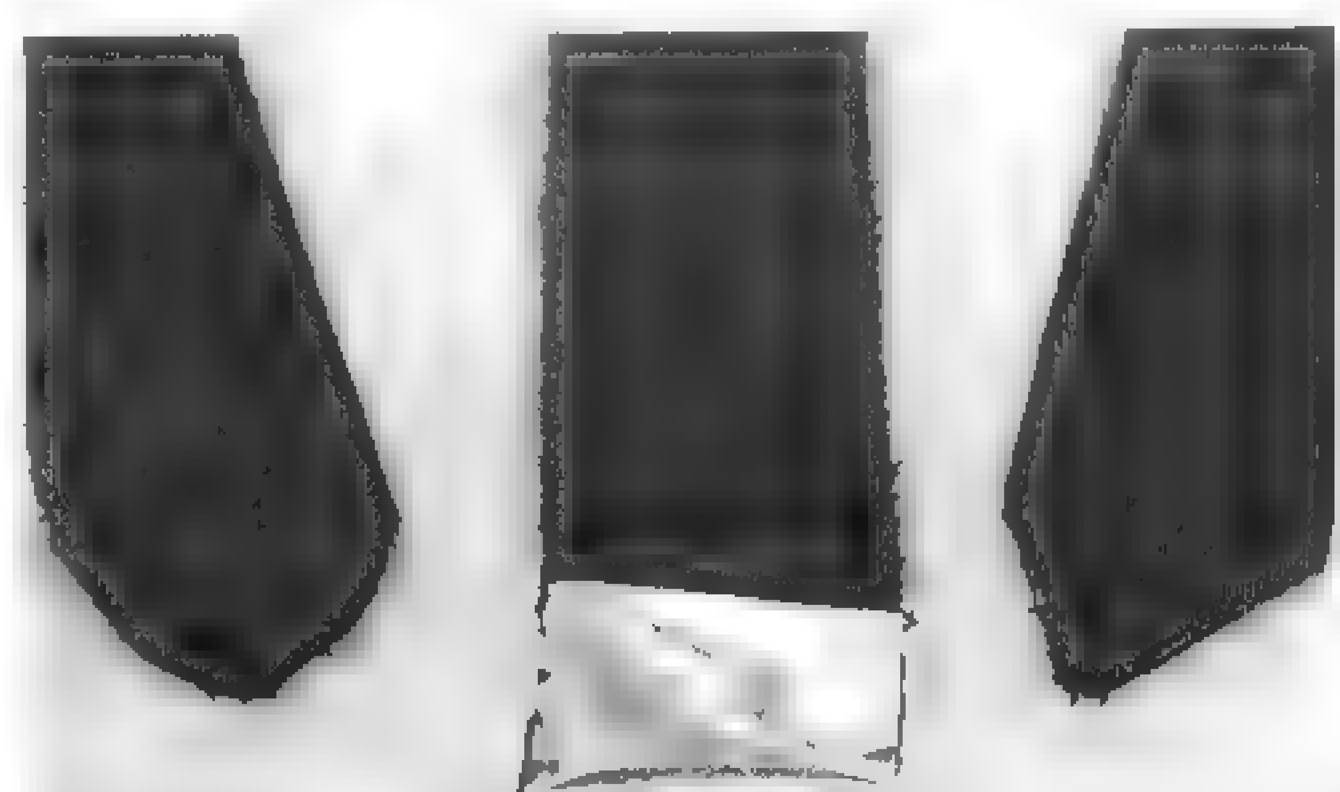


Figure 24.6. Tips on straps can be finished in a variety of ways

PUNCHING HOLES

After cutting, holes are punched at the appropriate places. For common 1/2 inch straps (as are often used on arm harnesses), a simple 5/8 inch oval punch roughly 5/32 inch wide will suffice nicely. This is placed approximately 1 inch from the edge and a flanking hole set between 1/4 and 5/16 inch from each side of the oval.

To make the round holes in the male strap, use either a rotary punch or a single-hole hammer punch on the end of a piece of wood. If using a rotary punch, it is advisable to put an extra piece of leather under the first piece to protect the small brass anvil under the punch. This will greatly lengthen the amount of service from the punches.

There are three methods to make the oval hole in the female strap. The best is to place a commercial oval punch over the desired location and tap a few times (fig. 24.8). You can also use a round punch, making two holes (one at either end of the desired end of the oval) and cutting the rest out with the box knife. The last is a field expedient whereby you simply punch a series of holes next to one another to approximate the necessary shape. Once all the holes have been punched then the leather can be dyed.

Figure 24.7. After a trimming tool has been run over the edge of the leather to bevel it, it is ready to have the holes punched. If no dying is to be done, the edge can be waxed smooth. Otherwise the waxing should be done after dying

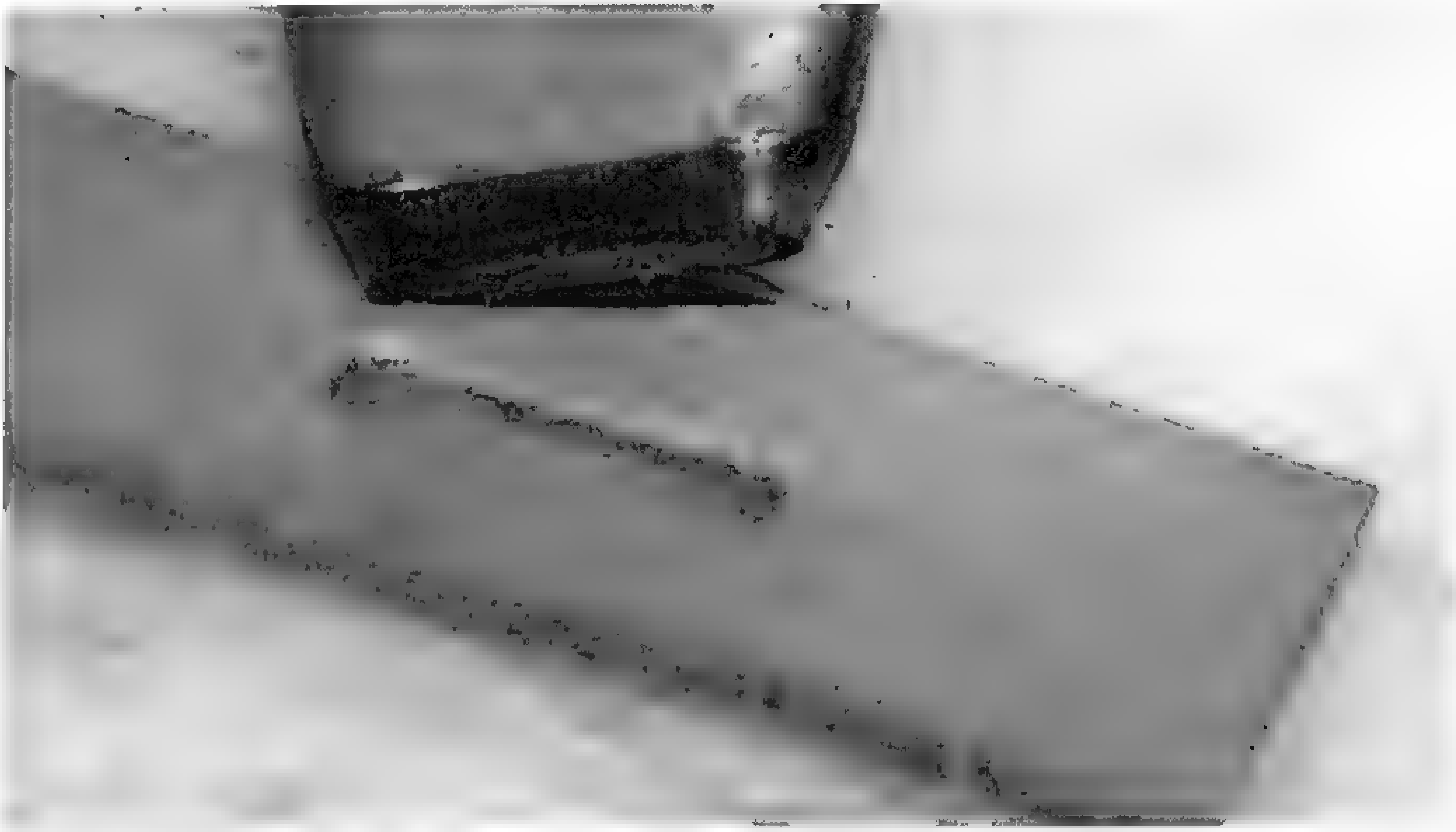


Figure 24.8 A commercial oval punch greatly speeds the creation of the hole needed to accommodate the buckle

Figure 24.9 The buckle can be held in place by a variety of means, including (left to right) the modern speed rivet, a shaped truss or round headed rivet (backed with a washer), or stitched with linen thread

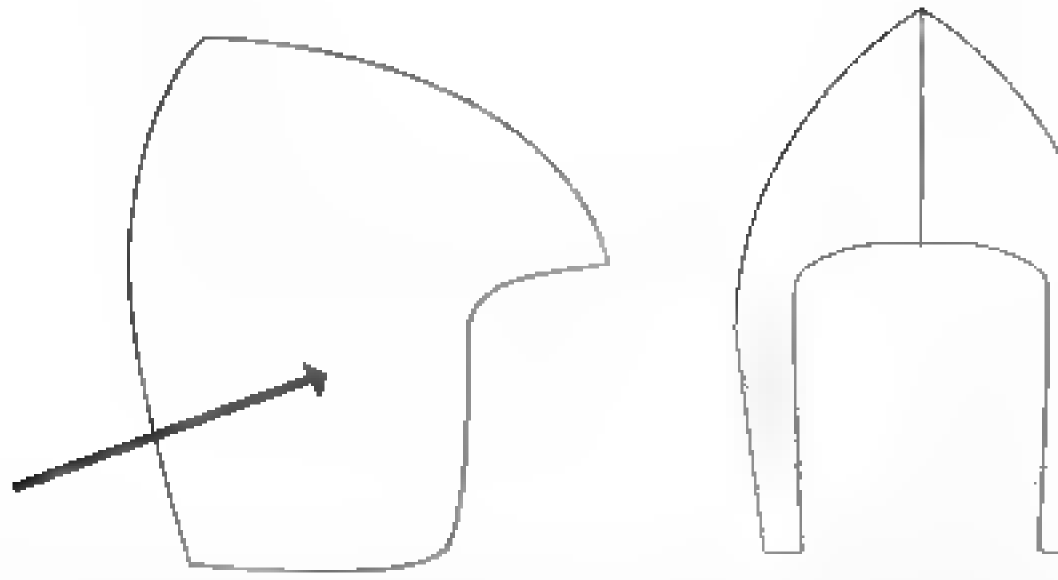


Figure 24.10. Place the helmet chin strap just below the ear on each side of the helmet. The buckle should extend to below the lower edge of the helmet so that it remains accessible to the combatant. The use of chin straps on bascinets and similar helmets is decidedly anachronistic but it is usually a modern safety requirement

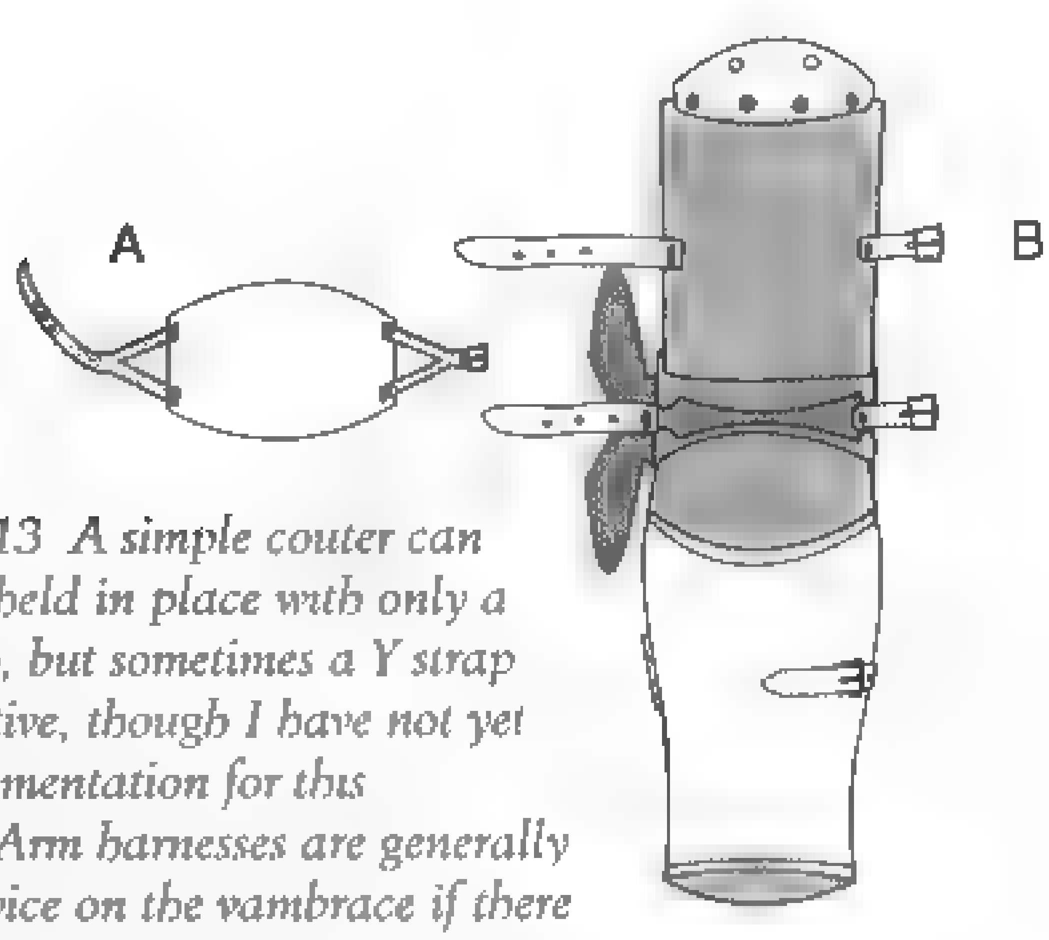


Figure 24.13 A simple couter can be quickly held in place with only a single strap, but sometimes a Y strap (A) is effective, though I have not yet found documentation for this technique. Arm harnesses are generally strapped twice on the vambrace if there is no wrapper, but only once if one is present. The rerebrace is held by a single strap only if it is not fully enclosed. The leather flap at the top is pierced with two holes and is used for securing the arm in place with arming points attached to the gambeson. A strap at the elbow seems to be a common to the few remaining examples, but many reenactors have found the harness often works just as well without it

Figure 24 11. Most 14th century breastplates are held in place with straps crossed in the back The short straps represent the female straps to which the buckles are attached.

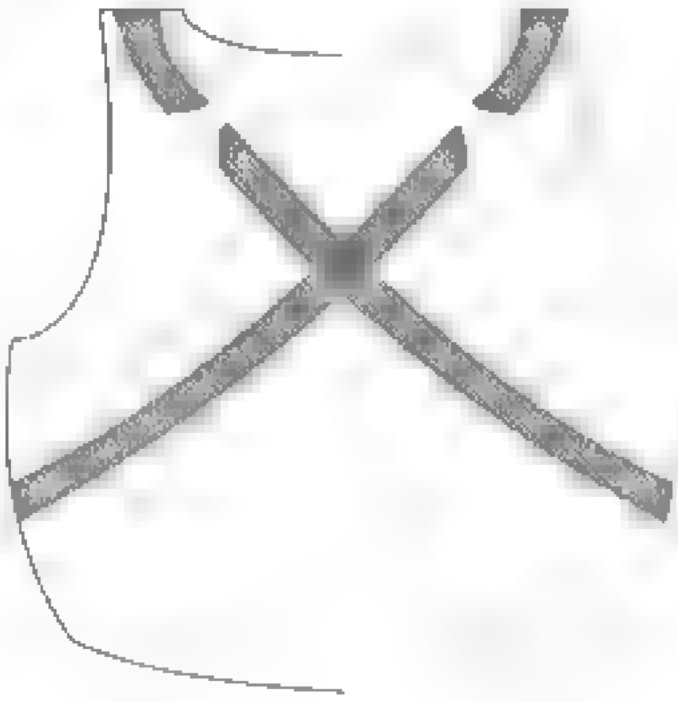
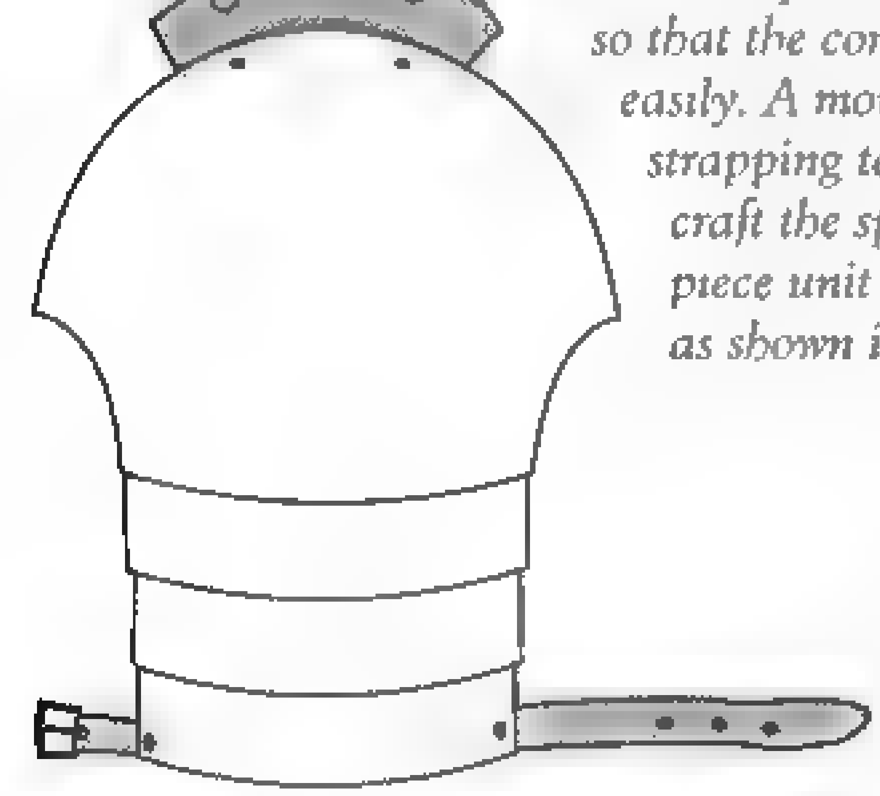


Figure 24.14. A single strap across the palm will hold most gauntlets in place. The strap should not be too thick, but it should be tough.

Figure 24 12. Spaulders are generally strapped with only a light strap on the bottom lame, the buckle located on the inside so that the wearer can get at it. The flap of leather at the top is used for the arming points attached permanently to the arming coat. The buckle strap is short and should be placed toward the inside so that the combatant can reach it easily. A more common strapping technique is simply to craft the spaulder as a one-piece unit with the rerebrace, as shown in Figure 20.3.



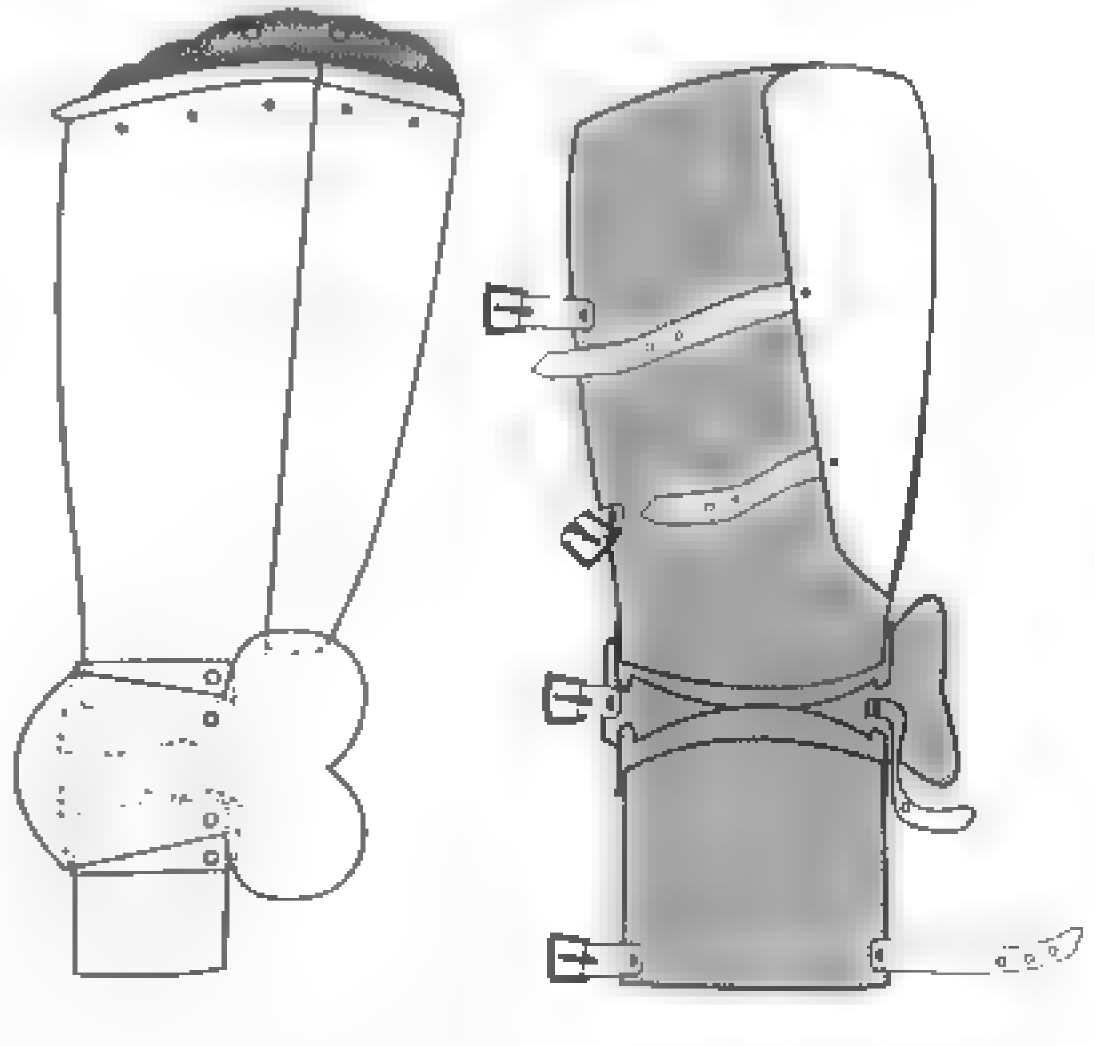


Figure 24 15. The buckles on the legharness are placed for ease of use, two behind the cuisse and one at the base of the demi greave Some people also prefer one behind the knee, though the author has rarely found it necessary

Once the leather has been punched, dyed, and waxed, the buckle can be attached. If using a commercial two-piece belting rivet, the male end is run through the bottom and the cap is placed over the top. If using a truss- or round-headed rivet, a small washer is used on the back to hold the rivet in place.

To attach a buckle using waxed linen thread, holes are punched in slightly different locations and the leather stitched instead of riveted (fig. 24.9).

WHERE TO APPLY STRAPPING

Once the armoured elements are complete, straps need to be affixed to hold them in position.

Helmets

Some medieval helmets were fitted with chin straps, but most were not. Modern helmets used in reenactments must often be so equipped to keep with rules' standards that govern their martial art. Check with the local standards.

In general, chin straps mount from inside the helmet through single holes pierced at or just below the ear. The buckle is traditionally on the right side, and it is convenient to make the strap long enough so that the buckle can be gripped with the right thumb just below the cheek line: otherwise the combatant is forever fishing around for it once the helmet is on.

I tend to use a roofing nail to secure chin straps in place, the head on the inside and the end clipped and piened from the outside. This can often be countersunk to make it invisible (see Figure 17.5), something that is especially useful where no chin strap is historically appropriate.

Medieval klappvisors did not have any straps at all, since they were made to quickly raise and sometimes discard. Indeed, on horseback the movement of the visor against the helmet contributes to the range of vision, greatly expanding it as the occularia moves up and down.

Modern visors must often be secured in some way to prevent them from becoming dislodged in combat. The usual method is to take a 5/8 or 3/4 inch strap and run it around the helmet, usually just above the vervelle line. This too is generally applied with roofing nails countersunk to conceal the presence of the rivets and downplay the presence of the extra strap.

Cuirasses

The strapping of a cuirass depends upon its style. Wisby-style brigandines (like the #7 produced in Chapter 31) have a single strap and buckle in the back, augmented by a simple triangular lace that holds the coat of plates in place.

Breastplates are usually strapped in a cross pattern with a strap from each shoulder that crosses and attaches under the arm. A third strap is sometimes used across the lower back, but this seems to have been a special requirement of the segmented globose rather than the ordinary breastplate. Full cuirasses are generally strapped at the shoulder and under the arm.

Shoulder and Arm Harnesses

Spaulders are generally fitted with a single strap that extends around the upper arm and an arming point at the top. This point is generally attached either to the gambeson, to the straps on the breastplate, or anachronistically to the gorget. If attached to the gambeson, the fit of the garment must be precise or the spaulder will "wander" from front to back in the course of use. Buckles are generally on the inside of the arm rather than the outside so that the strap ends point inward rather than outward. Generally a 1/2 inch strap and buckle is sufficient.

Arm harnesses are the same. For anything less than a full vambrace two buckles are used, each roughly an inch or two from their respective edges. On full vambraces sometimes a single strap is used, attached to the inside wrap plate and buckling on the outside.

Couters often—but not universally—have a strap across the elbow joint designed to keep the elbow in place. Sometimes a Y strap is used for this purpose, especially when combatant elects to use a floating defense rather than an

integrated articulation. These straps should be narrow and not thick or they will impede the closing of the elbow; 1/2 inch, 4 to 6 ounce leather is sufficient.

Rerebraces are generally only worn when they are part of an integrated articulated defense and contain a single buckle plus an arming point at the top. This point should be arranged such that the arm defense balances and does not cant to either side when suspended by it. This balance of the harness will help it to stay in place when worn. For all arm harness straps, a width of 1/2 inch seems to be best.

The arming point is a half-circle-shaped piece riveted to the rerebrace with two arming nails and punched with two holes to accommodate the arming points that will be attached to the gambeson.

Gauntlets

Generally the only strap required for a gauntlet is a palm strap. This strap, cut from 4 to 6 ounce leather 1/2 inch wide runs across the hand and is held in place with an arming nail at each end.

Legharnesses

All buckles on legharnesses tend to be on the inside, even though this is sometimes a bit uncomfortable for the horse. I tend to use 3/4 inch straps for these, although 5/8 or even 1 inch will work. Legharness straps should be of heavier leather (9–11 ounce), as a great deal of stress is put on them as a combatant moves and kneels.

Two buckles are placed on the cuisse. Sometimes an additional buckle is placed at the base of the demi-greave as well. Some combatants like a buckle behind the poleyn, and medieval examples show that this was done at times. Be careful in this case not to have the buckle fall behind the knee when a combatant kneels or it will prove uncomfortable.

Many reenactors use straps at the top of the cuisse rather than the medieval arming point solution. If used, these straps should be of a thick material and should not be less than 1 1/4 inch wide. Arming points are preferred, but

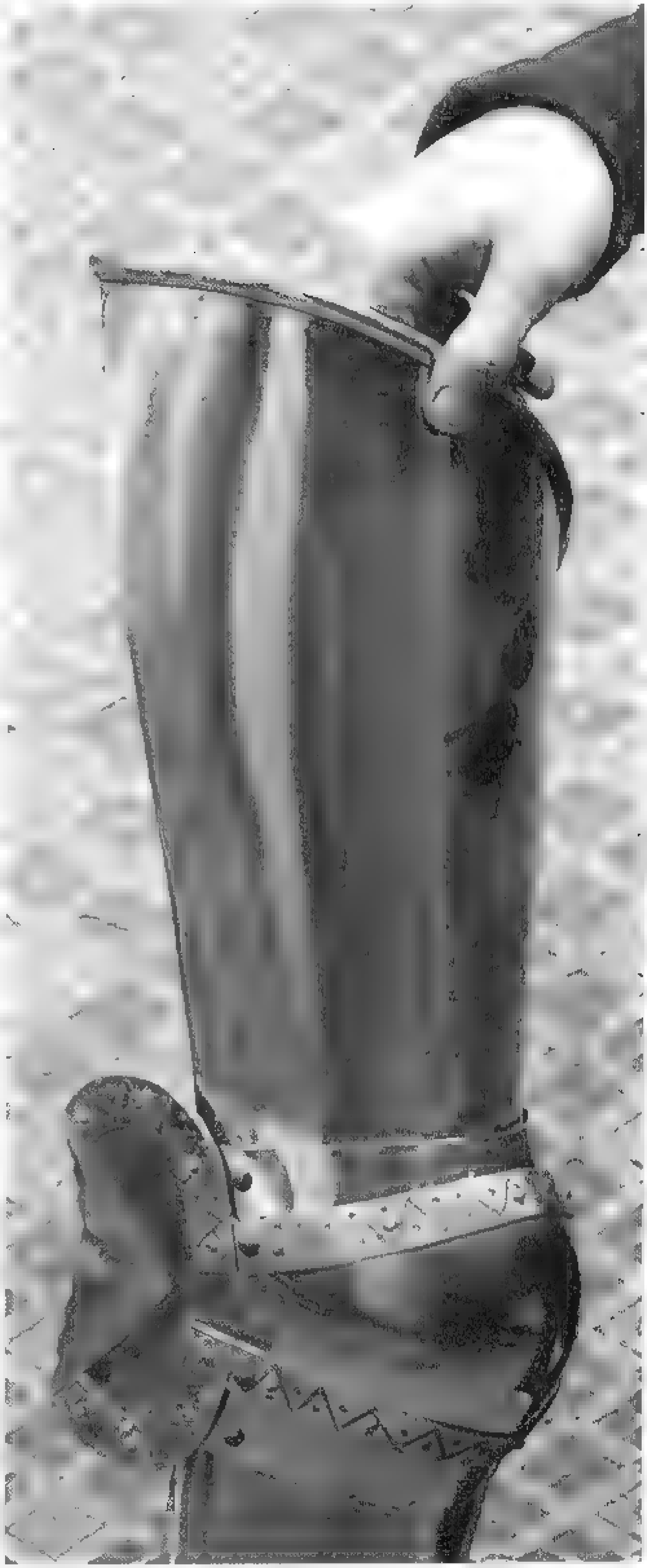


Figure 24.16. In order to sit on the leg without twisting uncomfortably, the legharness mounting point should be placed at the balance point. A little experimentation will reveal the correct placement

they require arming hose, a pourpoint, or special belt. This strap should be placed at the point where the legharness balances or the defense will cant painfully to one side or the other when worn (fig. 24.16). Simple experimentation holding the harness up at various points will reveal the correct placement.

Some medieval arming points extended at several places around the top of the cuisse so that the legharness could be laced to several points. This would greatly improve the stability of the harness, but I have not yet seen a reconstruction of this technique. If a single point is used, then it must be of very durable leather and should be at the same balance point as was noted for the strap above.

When straps are used on greaves, they are usually on the inside and are of thin, 1/2 inch wide material. Sabatons are held in place by laces that go completely through the metal and are tied on the outside, although there are examples where an encased toe plate is fitted with a piece of leather such that the foot simply slips into it.

Chapter 25

Padding and Arming Points

Once the armour is strapped, it must be suspended and worn over the appropriate garments to protect the body from the impact of steel on flesh. Medieval padding did not consist of foam, as is so often used in modern reenactments, but was rather a mixture of wool, linen, fustian, and horsehair.

In the 14th and 15th centuries there were two main ways of providing the needed padding. The usual technique was to sew tubes of linen, wool, or fustian and to stuff them with a variety of materials, including horsehair, linen, or wool. Medieval padding was not quilted in the modern sense but appears to have been simply packed into long pockets that were then sewn closed—this applies both to helmet padding and to gambesons or arming coats. Another technique, documented from a single source, indicates that simple wool "blankets" were wrapped around the knees to keep the legharness from chafing.[2]

Arm and legharnesses, as well as the pauldrons or spaulders, were generally held in place through the use of woven "points" sewn directly to the arming coat or pourpoint, a sturdy garment worn under the gambeson as a platform for attaching the hose, and possibly the legharness as well. The arming points were eventually copied for use on civilian clothing,

Opposite page: Figure 25.1 An arming coat or gambeson is key to the proper mounting of a harness. This one was crafted by David Randrup of Los Angeles, California

and although no military versions survive today, some civilian examples do—indeed a fortunate circumstance.[3]

A surcoat, houpelande, or a kind of loose shirt was sometimes worn over the armour, although this practice seems to have gradually died out by the end of the 15th century. This garment provided some degree of protection from the sun but was mostly worn as identification and decoration after the 13th century. For a fine, relatively obscure reference, see the combatant in Figure 3.1, a detail from the Trebôn altarpiece.

Sadly, many modern reenactors are poorly turned out in terms of these important details. Medieval solutions, being the product of hundreds of years of experimentation under field pressure, generally work far better than their modern equivalents. Most modern helmets, for example, are padded with ordinary closed-cell foam, the same stuff that camping mats are made from. Yet because there are no guides, many helmets end up being padded by trial and error, often with too much padding so that the helmet is precariously balanced atop the head instead of fitting snugly around it.

Gambesons—when they are worn—are often based on modern patterns rather than medieval designs, and the results are mostly unworkable if well intentioned. Synthetic quilting and cloth are sometimes used, but from a pragmatic standpoint these fabrics don't breathe and as a result contribute to combatant overheating. It has taken years to rediscover what few resources remain, and experimentation over this time has created some very useful information. Many combatants still wear no gambeson at all, and yet this often misunderstood garment is the key that binds transitional and 15th century armour together, since it was largely affixed to the garment rather than to other plates as was common in the 16th century.

Likewise, modern reenactors normally eschew greaves and attach their legharnesses not to the pourpoint, gambeson, or hose but to a separate "kidney" style belt. The result is a functional but uncomfortable solution (fig. 25.9). While some creative designs for more

Figure 25.2. Medieval underwear consists of a linen shirt bries, and hose that lace to the bries These were made commercially from the reenactment supplier Black Swan

comfortable belts have been devised, the weight of the legharness is still suspended from narrow strips rather than being partially suspended from a case-fitted greave.

Lastly, medieval footwear should be worn wherever possible, as the modern "engineering boot" has a decidedly modern line and will not accommodate a case-fitted greave. While this is a reasonable way for beginners to start, intermediate combatants should attempt to upgrade their footwear to complete their accoutrement.

Fortunately, modern reenactors frequently opt for a form of surcoat or houpelande, and this can cover a myriad of inaccuracies (fig. 25.14). These garments are relatively simple to make and, as a result, many combatants achieve a passable appearance without significant cost or trouble.

Part of the reason for these inaccuracies is that historical references are few, so reenactors have had to attempt reconstructions based on very little information and have come up with solutions that are based on similar, though decidedly different, problems. The information presented in this chapter discusses both the historically accurate methods as well as modern alternatives for those with less in the way of resources.

ARMING CLOTHES

Medieval underwear generally consisted of linen or silk "bries" (briefs) and a simple under-

Figure 25.3 There is a single reference to wool "blankets" being worn at the knee, and experimentation has revealed that the blankets are more comfortable than modern knee pads. For the most part a well-made medieval boot of heavy leather provides protection for the knee, enhancing the blankets worn underneath.

shirt of the same material (fig. 25.2). Usually this linen would have been undyed natural fabric, probably buff or off-white in color.[4]

Over the bries and shirt would be worn "chausses" of wool, linen, fustian, or some other durable cloth. These chausses would be laced to the undershirt or pourpoint with woven points of silk or linen, sometimes tipped with metal chapes. The pourpoint itself was probably a stout garment of a tightly woven, durable, natural material, possibly like modern canvas.[5] Unfortunately no historical examples survive, so this is mostly speculation based on literary references. In the last few years some commercial entities such as Black Swan have offered garments like these for sale, and the result has been a much wider acceptance of medieval underclothing within the reenactment community.

Over the chausses were wrapped woolen blankets (fig. 25.3), probably pinned into place with the medieval version of a safety pin, that protected against chafing by the legharness against the knee.

Modern reenactors often opt for a much more inexpensive solution by wearing commercial sweatpants. While inauthentic, the effect is similar and easy to obtain. Some combatants wear modern sweatshirts or t-shirts under their gambesons or, less attractively, without a medieval covering at all.

Instead of blankets, most modern reenactors wear some form of foam knee pad as is used by wrestlers or rollerskaters. While they are easy to acquire and inexpensive, foam pads held in place with powerful elastic is not exactly a comfortable solution, especially since the foam does not breathe and the elastic is constricting.

In my case, I have elected to wear a heavy medieval boot that extends several inches above the knee (fig. 25.3). When the leg

Figure 25.4 On this detail from the Isenheim Altarpiece, the "stuffed" defense common to both gambesons and some helmet padding can be plainly seen. The tubes were sewn first, then stuffed with fustian or linen, then sewn closed.

harness is worn over the boot, this combined with the blanket defends the knee against chafing and avoids the unpleasantness of the knee pad. With case-fitted greaves the boots become superfluous, and low-cut medieval shoes should be worn instead.

As I stated above, the gambeson is the most important and yet the most misunderstood component of the combatant's garments. Evolving from the padded aketon worn under mail shirts, the gambeson, or arming coat, is aptly named since it is a coat in its own right. Providing both protection and warmth, it is likely that heavier garments were worn in northern Europe and lighter versions in the south.[6]

ARMING POINTS

Attached to the gambeson or pourpoint are the woven points that are passed through the armour to tie it in place (fig. 25.5). The points themselves are woven from linen or silk and permanently stitched in place. Sometimes these points are capped with metal, both to protect the ends from damage and to ease their passage through the leather attachment points.

It should be noted that the laces were usually not passed directly through holes punched in the metal plates but rather through leather tabs to reduce wear on the point itself and to help stabilize the plate.

THE POURPOINT

Plates must be well placed to be effective, which in turn indicates that the pourpoint or gambeson must be well fitting. A loose garment fitted with points would allow the plates to shift too far, a common symptom when spaulders and pauldrons are attached in this way.

There are even fewer sources concerning pourpoints than there are for gambesons, so

Figure 25.5. Woven arming points of linen and silk were used to tie the armoured elements to an arming coat or pourpoint. The pourpoint, in all likelihood worn under the arming coat, would have had strategically placed points for the legharness, while the arming coat would probably have had points for the shoulders and arm harness. The reconstructions shown here are available commercially from Historic Enterprises.

what follows is a theory based on reenactment experience and some research. Two illustrated sources from the 15th century show the pourpoint, a garment worn over the linen shirt but under the gambeson or arming coat (fig. 25.7).

The pourpoint is close fitting, as is required to hold the legharness in place, and may have been the precursor for the close-fitting cotehardie.[7] Plate cuisses came into fashion before the 1330s, just prior to the development of the civilian cotehardie. Cuirboille leg defenses—lighter than their plate counterparts—were laced directly to the mail chausses, something that is impossible with a steel cuisse and articulating poleyn. Because the harness pulls on the hips more, a close-fitting garment—the pourpoint—or a belt would be required to hold it in place. The final garment is attractive and, as had been well-documented elsewhere,[8] civilian fashion often follows the military—it is interesting that the tight-fitting cotehardie came into fashion just after the plate leg defense.[9]

In the Company of Saint George we have been experimenting with the use of the pourpoint, and the results have returned supremely effective and comfortable function. The pourpoint must be very close-fitting, however, so a skilled tailor or seamstress should be consulted. The garment consists of two layers, one of canvas and an outer, decorative layer (fig. 25.8). Lacing holes follow up the front, leaving only an inch between each eyelet. This closeness is necessary because otherwise gaps will pull the garment apart. The neck and arms are open as with the manuscript references. The points are sewn in place, though they could also pass through reinforced eyelets. To hold the cuisses in place, even without greaves, simply lace them through holes on the arming tab attached to the top of the cuisse (fig. 25.8).

Figure 25.6. The arming points are sewn to both pourpoint and gambeson. On this example by David Randrup the laces are simple shoelaces placed at the shoulder and upper arm to support an arm harness

Figure 25.7. The only illustrations the author has yet found of pourpoints, both dating from the 15th century. The illustration on the left is a manuscript illumination in the Nuremberg Museum, Germany (998, fol 2); the one on the right, dated 1430, is from the Bibliotheque Nationale, Paris (lat. 17294, fol 122 verso)

Figure 25 8 The author's prototype pourpoint, made jointly by the author, his wife, Ann, and Debora St James. In field trials this prototype has worked beautifully, in the final version the points will be moved a bit higher

A more common solution requires the creation of a wide, tapered belt in lieu of the pourpoint (fig. 25.9). I first saw this hip belt on the West Coast on Steve Beck, the person I've heard credited with the invention. It is a vast improvement on the traditional weightlifter's belt that has been used by reenactors for many years, but it does not compare to the pourpoint for comfort and function.

There is a debate concerning whether the medieval legharness was attached to a pourpoint or to laces on the interior of the gambeson. One of the remaining pieces—the Charles VI coat in Chartes—is fitted with points on the inside. While I am sure this was used, it would require the gambeson to be exceptionally well fitting and would probably preclude the cloth draping smoothly over the hips, a characteristic of clothing from the period as illustrated in numerous manuscript references.[10]

THE ARMING COAT, GAMBESON, GIPPON, OR AKETON

The gambeson or arming coat is the binding that holds a transitional harness together. It also provides an opportunity to add color in a heraldic theme and offers protection both by padding the plates and offering some defense for blows between the plates. Being cloth, however, there are few surviving examples and only a handful of references.

The Isenheim altarpiece (fig. 25.4) is perhaps one of the most important and less well-known examples. In it the combatant is shown bearing a helmet, aventail, and a single arm defense. Some padding at the knee and the gambeson are shown in excellent detail.

Another example is the coat of Charles VI, now deposited in Chartes cathedral (fig. 25.10). This coat, like others mentioned in manuscript references, is made with linen, stuffed with wool, covered in silk damask, and has laces at the hips. This would indeed give an effect similar to the pourpoint, enabling the interior laces to support the legharness. The coat of the Black Prince at Canterbury Cathedral is similar, though it is likely a funerary gament probably not intended for war. The Charles le Blois coat at the Musée Historique des Tissus de Lyons is another that is similar to the Charles VI piece, save that it is made entirely of silk damask stuffed with an unknown material.

In all of the above examples, the garments were sewn in tubes and stuffed with wool, fustian, or other lining material rather than being quilted in the modern fashion. They generally open down the front, using flat covered wooden buttons or, as in the case of the Black Prince coat, are laced. None of the

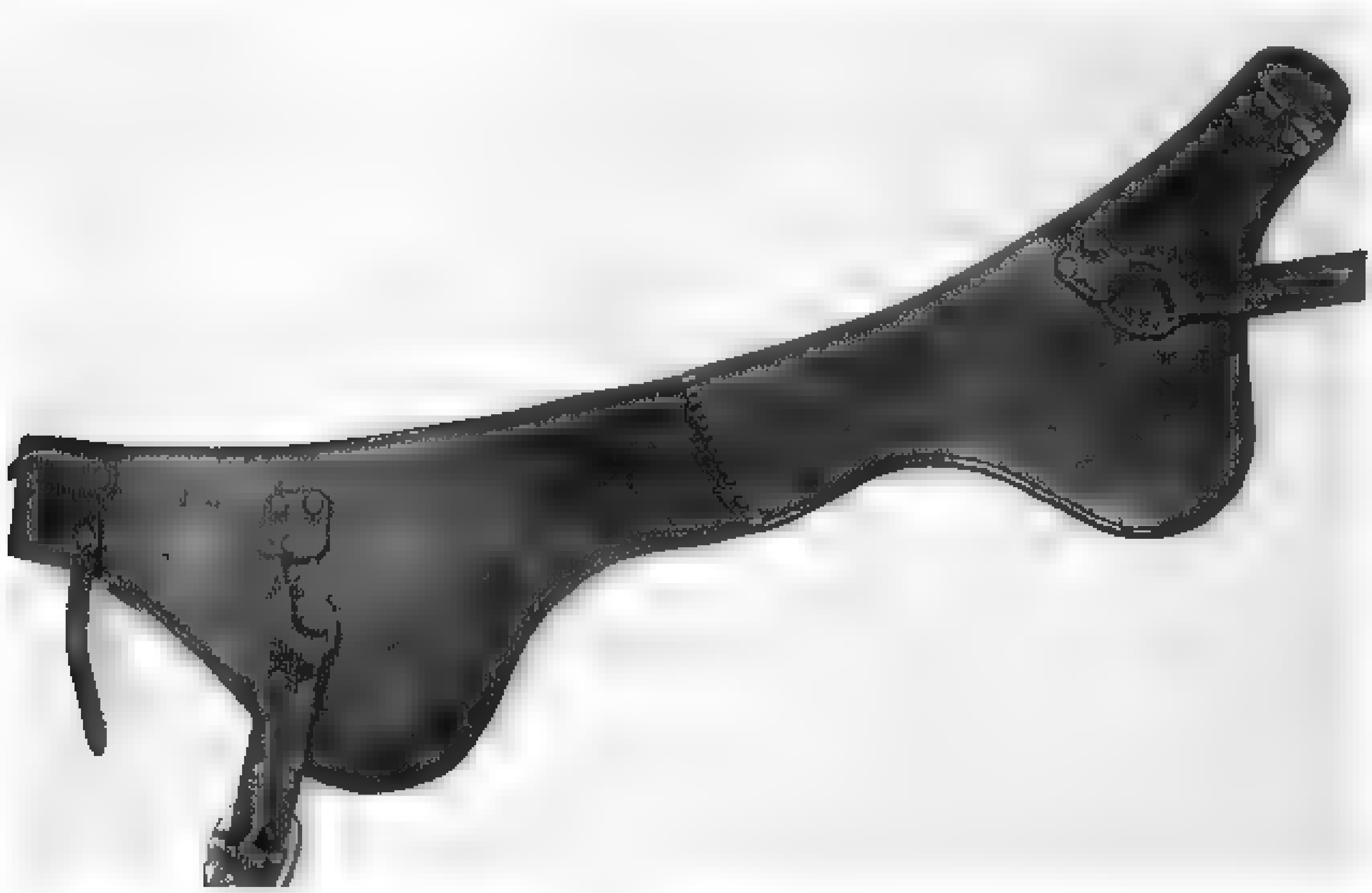


Figure 25.9. This is a variation on the kidney belt technique, which, while modern, has the advantage of being very easy to engineer.

Figure 25.10. Charles VI arming coat

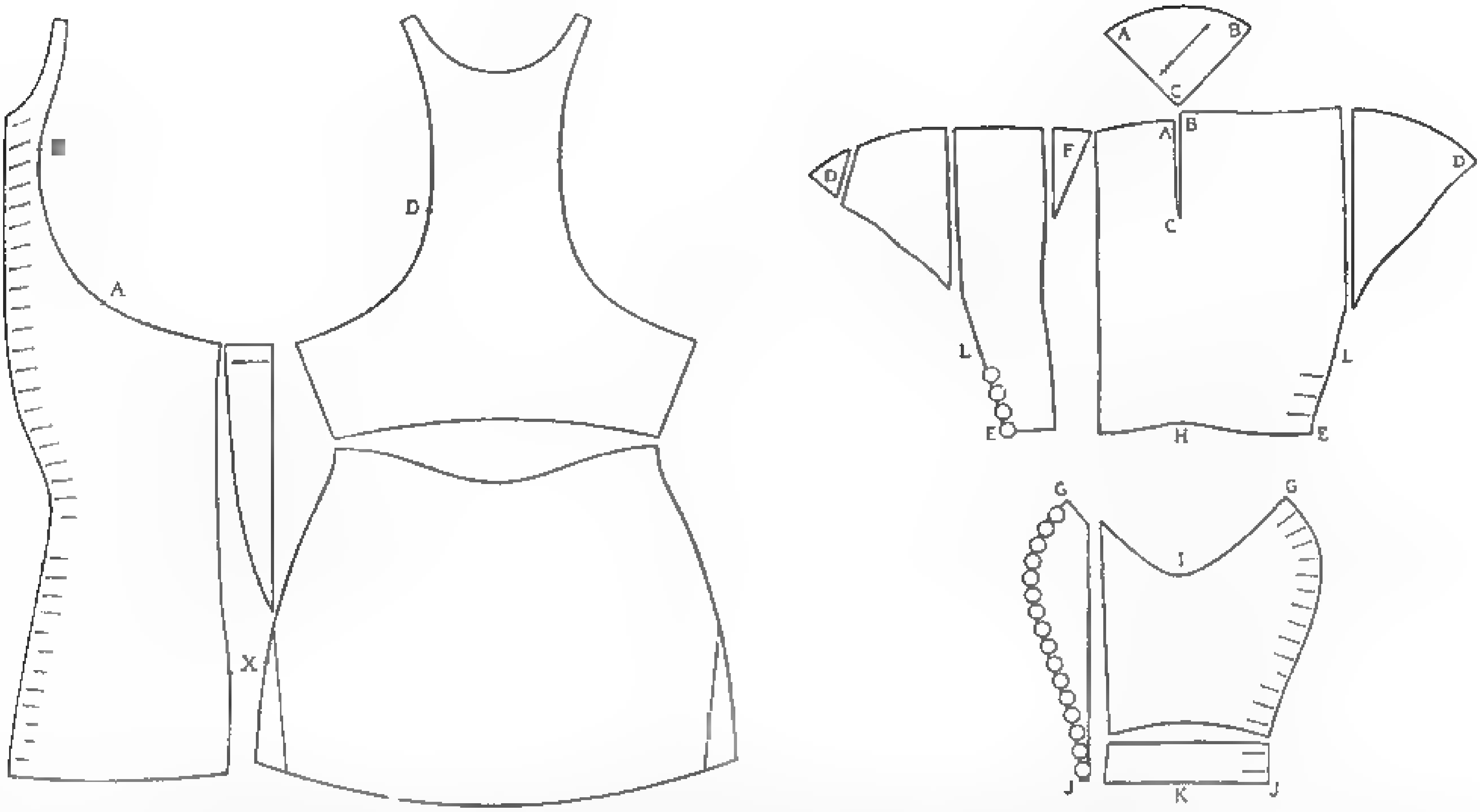


Figure 25.11. These patterns, taken from an early 19th century book on the times of Joan of Arc, seem to be correct and will allow the creation of a well-fitting gambeson similar to the one by David Randrup shown in Figure 25.1 or Debora St. James in Figure 25.13

aforementioned examples features a standing collar, but it is the author's opinion that they might have been used occasionally since other garments featured them and they made for a far more practical function by adding a comfortable layer of defense for the neck.

The most important element of the gambeson is the cut and attachment of the sleeves. Unlike modern garments, where the sleeve is set at the body, these garments are cut in to follow the line of the cuirass. Such a liberal setting of the sleeve yields the dual benefit of complete mobility and a counter to the tendency of the hem to rise when the arm is raised. Using natural fabrics there is no need to cut the armpit for heat or mobility, and there is no evidence for this being done on medieval originals. Choose a linen and stuff it with equally natural wool or linen and the results should be both comfortable and medieval.

The garment is cut generously at the chest, fitting tightly at the waist, flaring smoothly with the hips, and extending down to mid-thigh. The arms should be slit along the outside of the forearm and closed with buttons or, less practically, with laces. The arms should be loose fitting at the upper arm to account for the wide sleeve attachment needed for mobility, narrowing at the elbow and close fitting along the forearm. It should flare again at the wrist and will optimally extend all the way to the knuckle line, since in practice the vambrace will draw toward the elbow. Laces should be added on each shoulder at the neck for the spaulders and approximately 2 inches below the shoulder point to attach the arm harness.

Unfortunately, finding someone who can interpret these difficult but crucial garments correctly is a challenge for the reenactor or collector. A well-made gambeson requires many hours of labor and much knowledge that is generally gained only through experience. Most tailors and seamstresses refuse to make them, so if you should happen to locate one who has the knowledge and ability, treat him well.

Throughout the 14th century, arming coats and variants on the surcoat were often done in heraldic colors and emblazoned with bold

charges, matching the colors of the shield. Although the surcoat gradually disappeared throughout the century, particularly in Germany the flowery sleeved houpelande continued to be worn until the end of the century, a flowing enhancement for tournament reenactors.

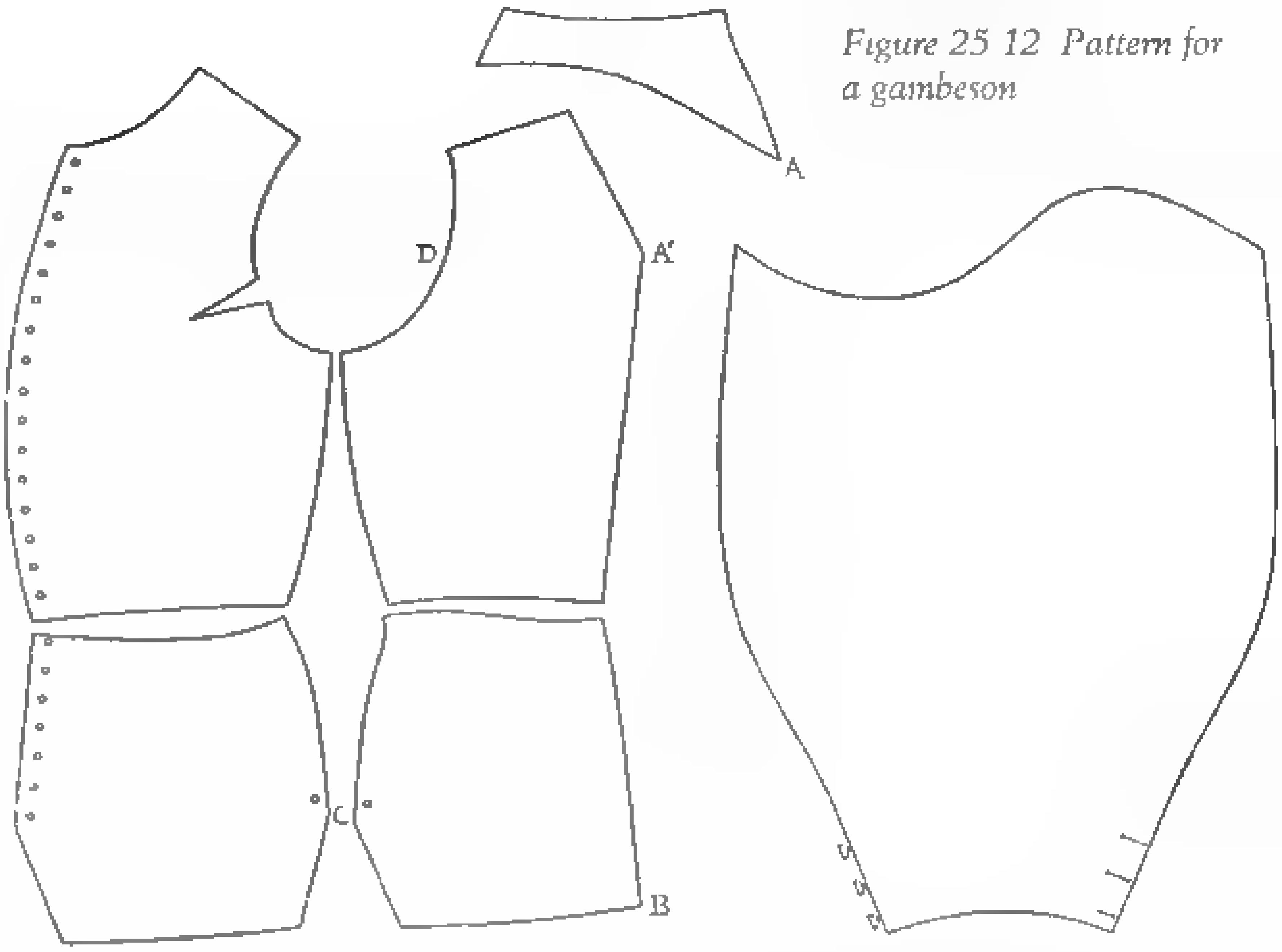


Figure 25 12 Pattern for a gambeson

PADDING ARMOURED ELEMENTS

As has been mentioned, the knees are padded by blankets wrapped around the knee or, anachronistically, with knee pads. The gambeson provides the padding for the shoulders, arms, and body, but the helmet requires its own padding, a lining of sewn linen or wool.

The bascinet and later helmets were not usually worn over the padded caps common to earlier defenses but rather were fitted with their own padding. On bascinets this padding was sewn into the helmet directly through a line of holes punched around the helmet's edge.

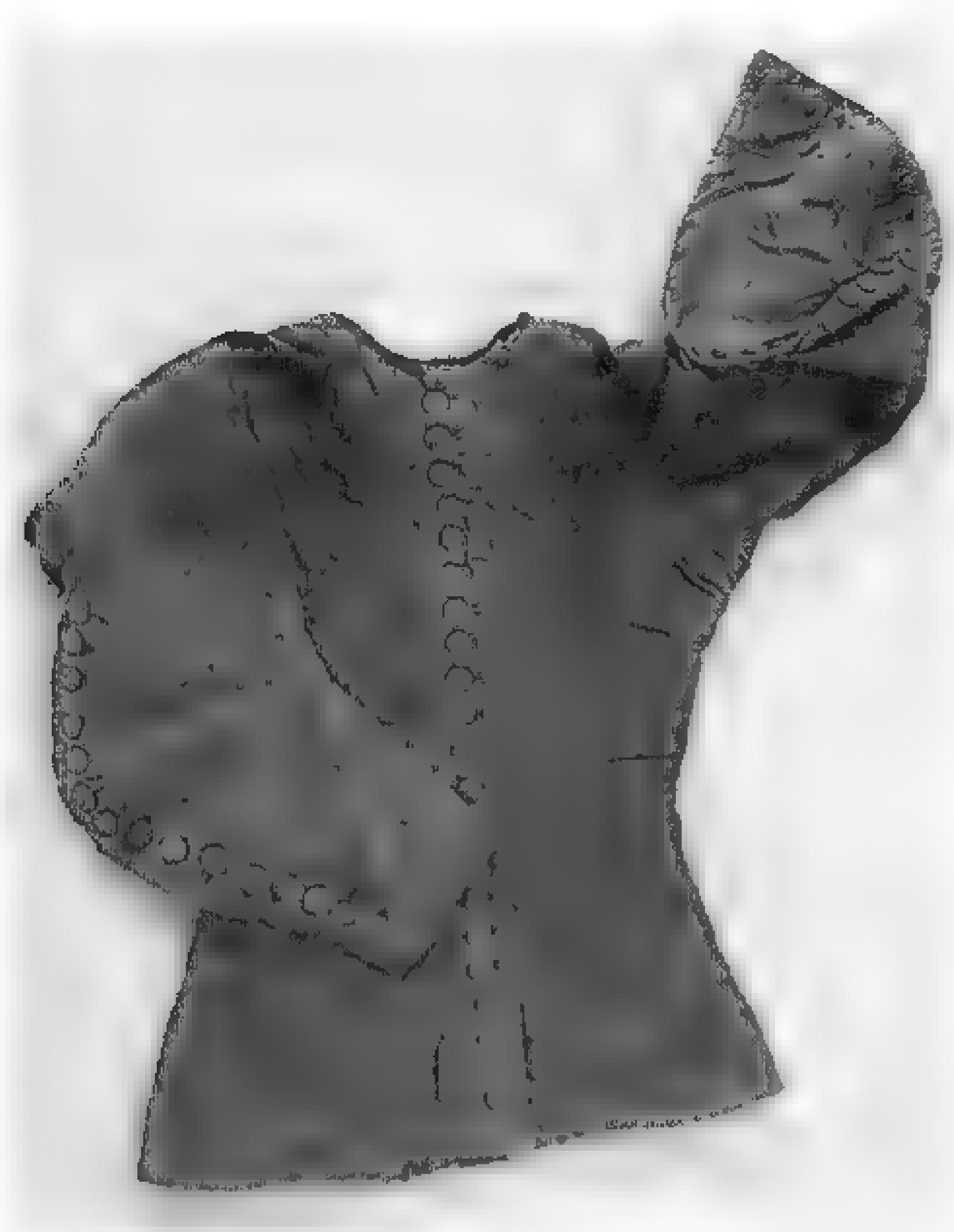
Only one example of this kind of padding survives, a particularly fine specimen preserved in the collection of Schloss Churburg. In the Churburg original, the lining is sewn directly to the helmet through the many 3/32 inch holes that have been pierced roughly 3/8 inch from the helmet's edge. It is made from two layers of linen stitched into pockets (a similar technique was used for gambesons, though these appear to have been stuffed with linen, wool, or fustian, probably scrap materials) and is drawn to a close at the top, which allows the height of the helmet to be adjusted in the same way as is done with the U.S. Army's kevlar helmet. Cow hair has been packed tightly into the pockets to form a lining that remains cushy even now, 600 years later.

Nearly every other bascinet in existence has the same 3/32 inch holes approximately the same distance from the edge, indicating that this was the standard technique or a variant rather than an unusual treatment, as is the case with so many other unique surviving specimens.

In addition to this fine example, there are many manuscript entries referring to "Nicholas Brampton, stuffer of bacynets." or "Bacynet, 1 3/4, stuffing for ditto, 3/4". As will become obvious later, they are indeed stuffed with horsehair, or sometimes with linen as was done with gambesons. The Company of Saint George has experimented with both (thanks especially to the efforts of Robert Holland and Debora St. James) and has found them more than satisfactory both in terms of function and safety.

There are other manuscript references to inexpensive helmets being stuffed with straw rather than horsehair; presumably this was an expedient and inexpensive alternative. Years ago I came across another reference — though I have not been able to locate it recently — referring to the use of sea sponges for padding, but I don't know how valid this reference might be.

Unlike closed-cell foam, authentic padding breathes and yet absorbs sweat so that it doesn't tend to run into the eyes. There is no duct tape to stick to the hair. It is easy to adjust



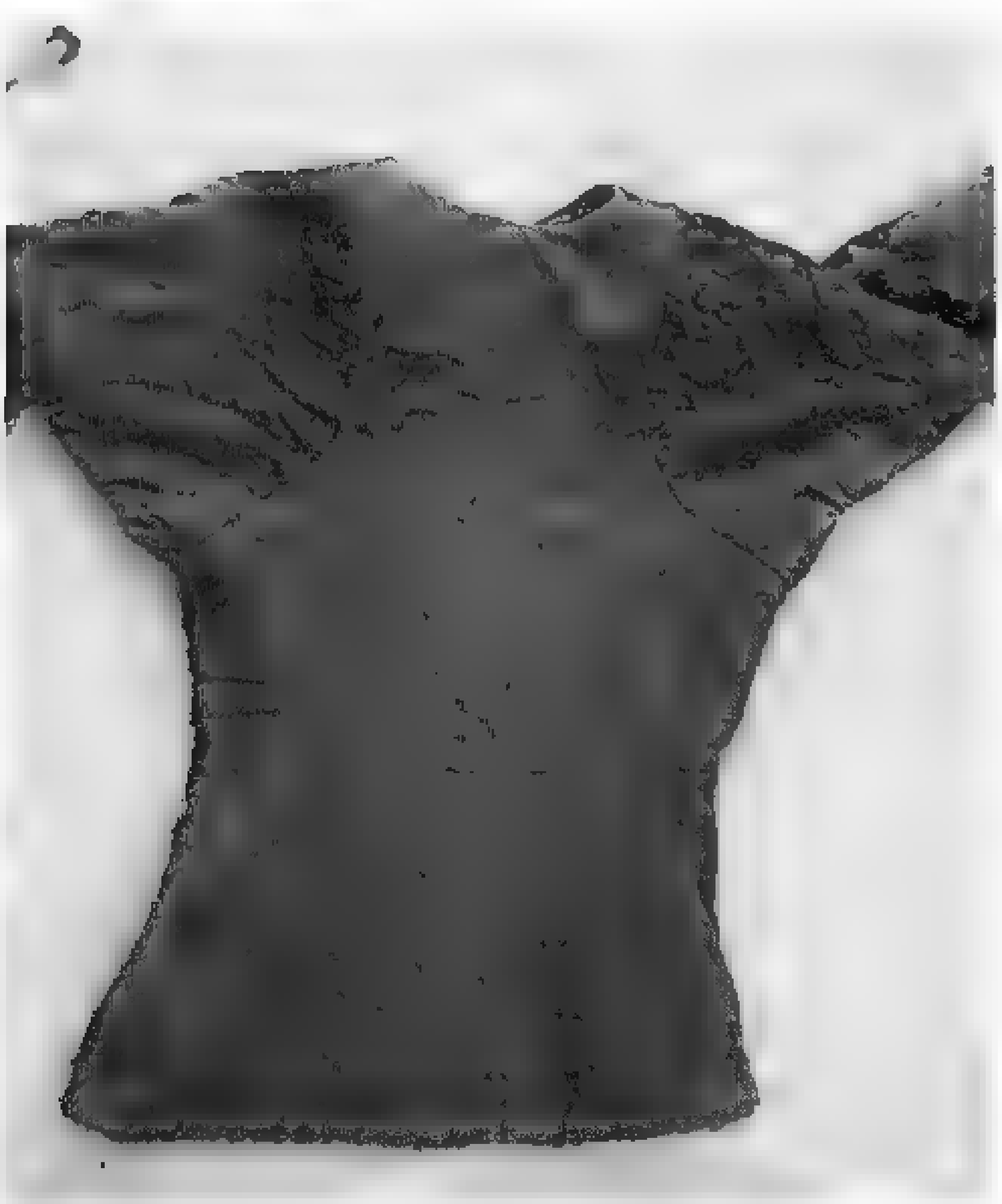


Figure 25.13 A fine gambeson made by Debora St. James of the Company of Saint George The outer shell is brocaded and the interior lined with silk

the helmet's height, so that the common "helmet too high on the head" problem is avoided. It can be removed and sewn back in approximately 20 to 30 minutes, so it can be washed. The padding does not appear to break down (the Churburg example is 600 years old!), unlike foam, so it should remain safe for years. There is no unsightly blue foam sticking out all over the place. When finished the inside of the helmet looks as good as the outside Because the horsehair doesn't break down and is stitched into the helmet or attached to a leather band that is riveted in place, the lining can't shift or deteriorate to allow the impacts sometimes seen over the browline when the more common foam is used. And best of all, it's authentic!

Although the technique given here is applied to the bascinet, similar solutions can be applied to any close-fitting helmet: the armet, sallet, barbute, or close helmet.

The first step is to drill the 3/32 inch lining holes in the helmet approximately 1/4 to 3/8 inch from the edge and the same distance between holes (fig. 25.16). While a drill can be used, a large Whitney punch will make the job far easier. On a bascinet, the holes should extend all around the base of the helmet in an unbroken line around the face opening. Use a larger drill bit to countersink the holes on each side to reduce wear on the linen thread.

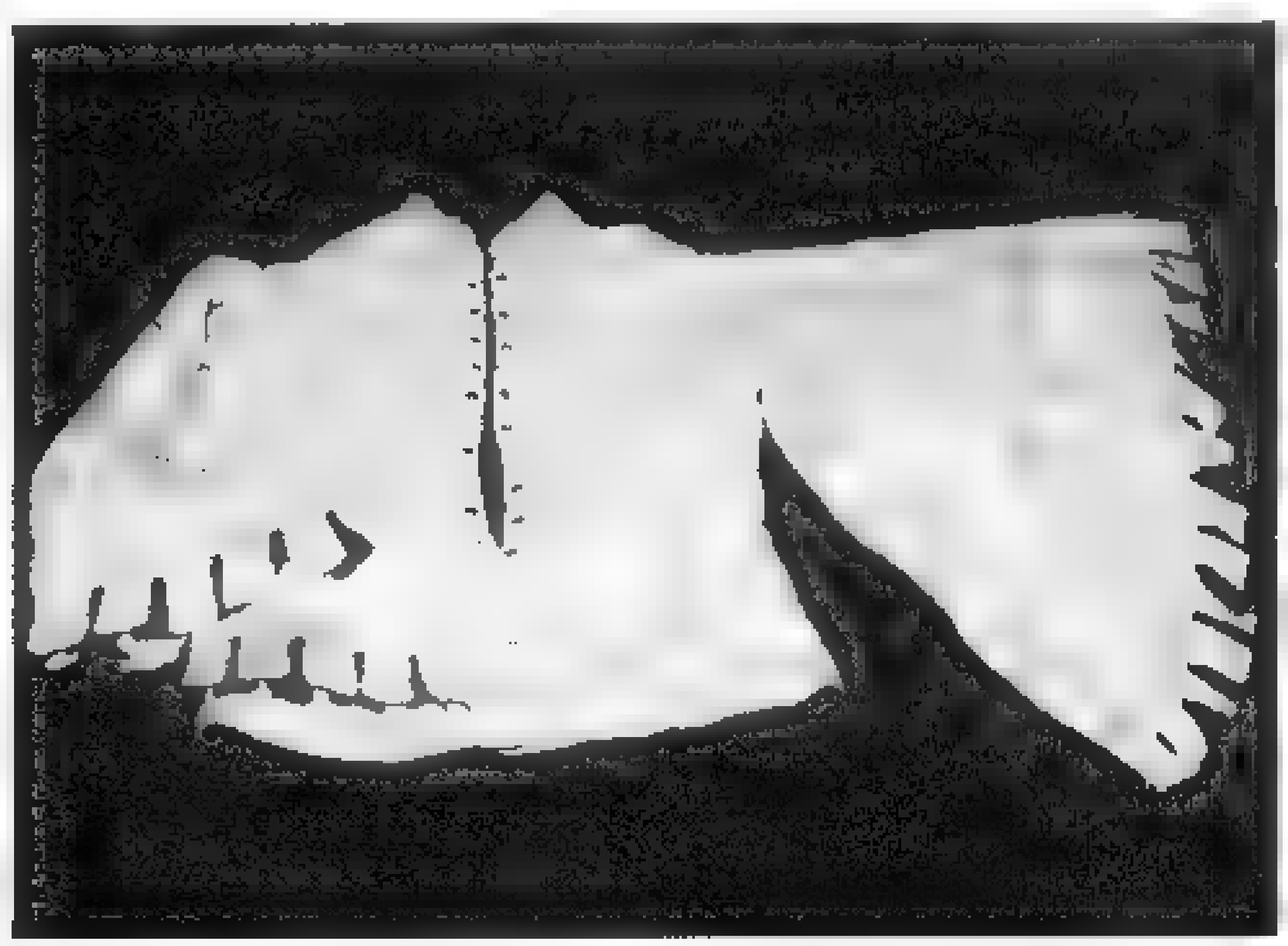


Figure 25.14. Fighting houpelandes

Once the helmet is ready, you will need 4 feet of linen or wool. Heavy, undyed linen is best. A light linen thread will be needed to stitch the liner together and a heavy waxed thread to stitch the whole lining into the helmet, along with an upholstery needle.

You will also need soft hair from the horse's body. This hair can easily be obtained from a local stable (fig. 25.18), where the shedding horses generate bags of the stuff as they are brushed (especially in spring). Be sure to get hair that has come from a horse that has just been washed or you might get enough foreign material to make cleaning it practically impossible. You will need quite a bit of material, usually a whole grocery bag (3 to 4 cubic feet, uncompressed)—far more than you'd think.

You will also need stiffer hair from the mane or tail (fig. 25.18, right), and this too can be obtained from the stable or purchased commercially. The stiffer hair will be wrapped around the softer to create a binding so that the soft hair doesn't distribute too much, but it is generally too stiff to use alone.

If you decide not to go to the effort of lining the whole liner with horsehair, then scraps of wool or linen will also work, albeit with a slightly stiffer result. Cut scraps into 3 inch squares and be prepared to stuff pocket after pocket, running through a goodly amount of material.

A pattern is first made from scrap material, cut and fit to the interior of the helmet. Be sure to allow for seams and adequate space; a dry run with the temporary liner stuffed with cloth or newspapers will help to finalize the pattern. It should fit along the interior of the helmet and will be used to cut the final version in linen or wool. The liner is divided into tubes that are quilted with the soft linen thread (which should also be used to assemble the rest of the piece). It is sewn with the bottom edge open to allow for the stuffing, after which it will be closed by hand with a needle and linen thread. The final piece is made of a single section of material folded down the rear centerline and joined along the top and front.

Eyelets are sewn into the top of the liner to allow for a drawstring. One anachronistic element frequently required is the allowance for a chin strap, which requires cutting a hole in the liner and stitching around it. Be careful to place this hole so that horsehair can be stuffed into the cavity above it or there will be empty tubes in the middle of your liner.

Small balls of horsehair are now rolled, wrapping the stiffer mane and tail hair around

Figure 25.15. This bascinet lining by Robert MacPherson shows a simplified version of the lining from Churburg #15

Figure 25.16 Bascinet holes

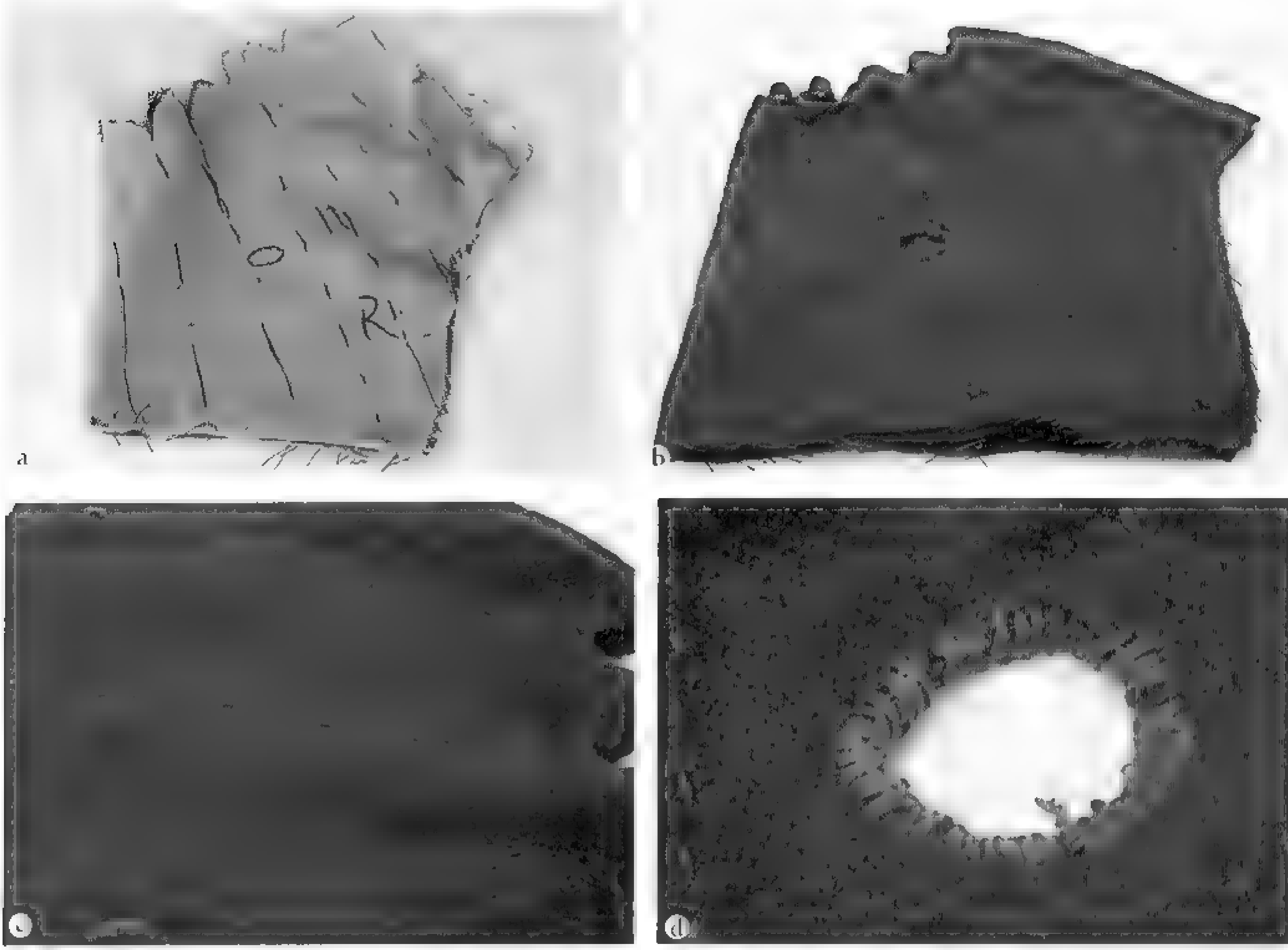


Figure 25.17. The test liner is cut from cheap fabric and marked with the tubes and the cutout for the chin strap (A). The test piece is fitted and when the fit is right it is used as the pattern for a piece cut from wool or linen (B). The tubes and the hole for the chinstrap are hand stitched (C). Be sure to leave space between the hole and the edge of the tube so that material can be stuffed into the top of the liner above the hole (D). Helmet liner of wool made for the author by Debora St. James.

Figure 25.18. Horsehair can be obtained from a local stable. Mane and tail hair can also be purchased commercially.

sets of pliers. If intended for combat, it must be heavier than most medieval mail because otherwise it does not stand up to repeated strikes with a bâton or blade. Even so, this kind of butted mail serves well at an exceptionally low cost, and indeed it is all that is available to most novice and intermediate reenactors. Some mail makers purchase premade links or springs from commercial suppliers, something that increases the cost but reduces production time.

A very few reenactors weld each link with a spot-welder (fig. 26.4), a process that adds to the time required to make the fabric but which allows the armourer to use thinner wire. Sometimes this is even done with stainless wire, which produces aventails of excellent durability and utility since they rarely, if ever, need repair.

In recent years there has been an increasing interest in the production of riveted mail. In the

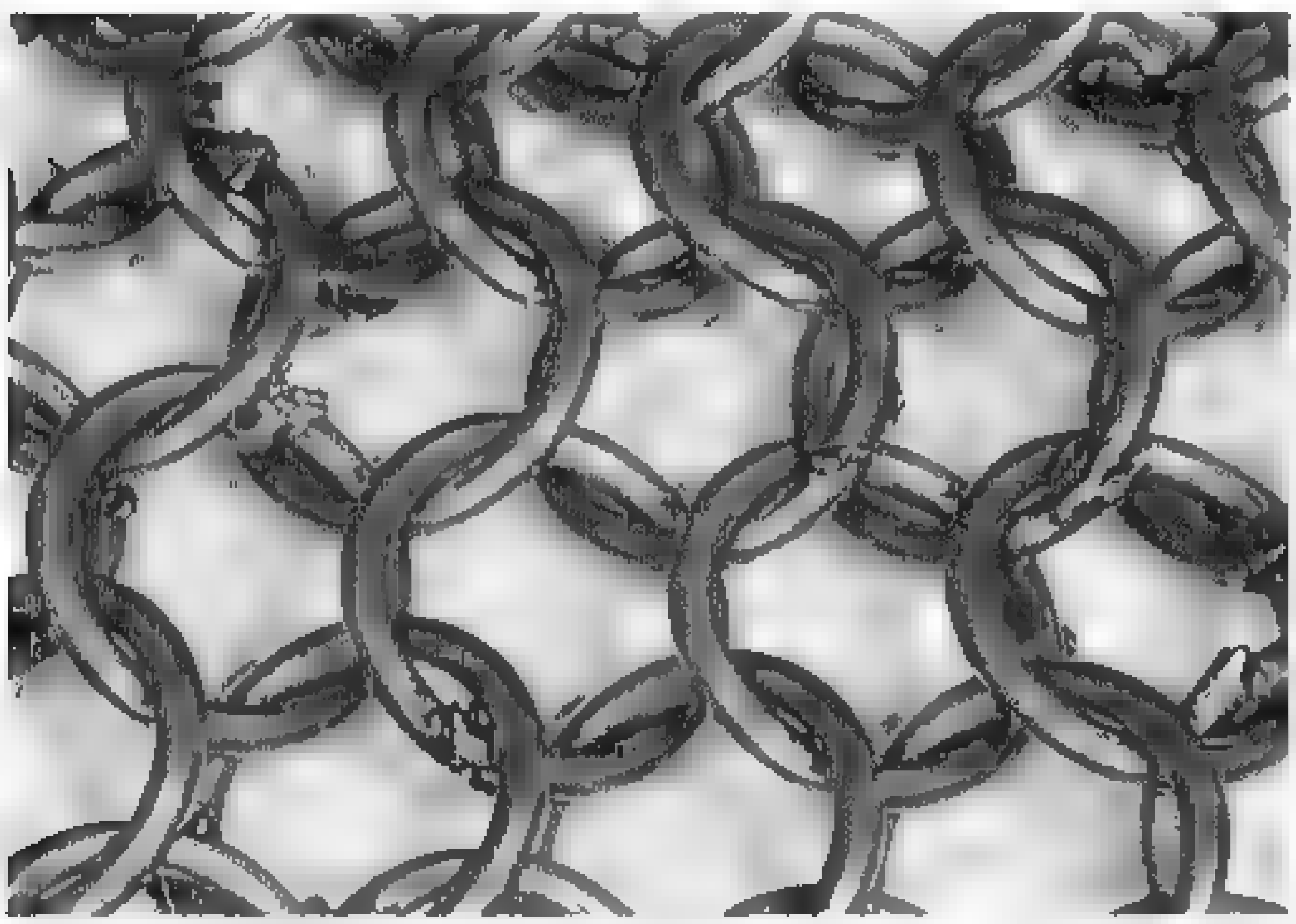


Figure 26.4. Detail of a welded aventail by Gordon Ostrum. This particular piece has been heavily fought in for two years and has no tears. It weighs 3.75 pounds. Because the steel is not polished the glaringly anachronistic material does not intrude unduly for most reenactment purposes.

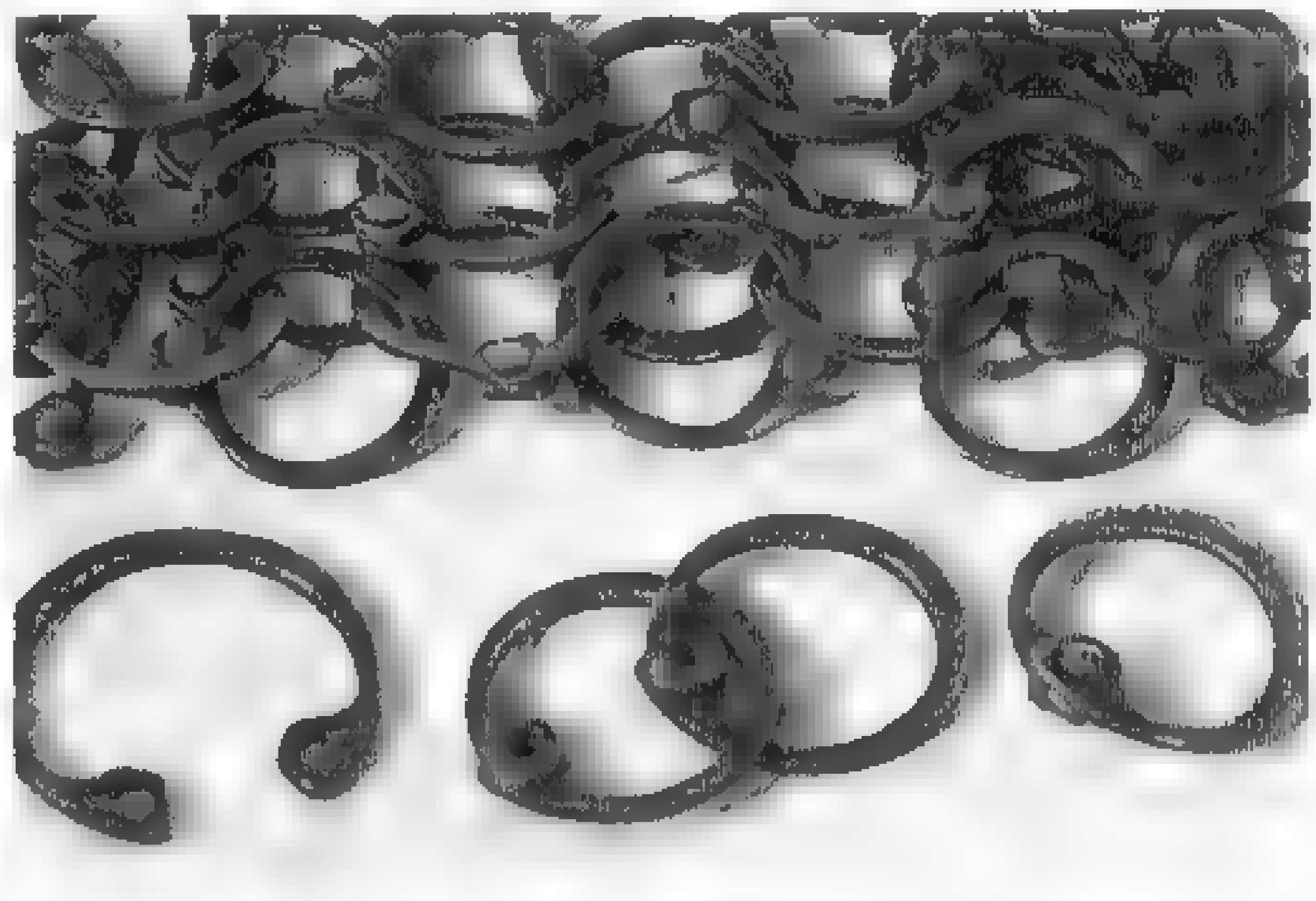


Figure 26.5. Some mail makers have been using internal retaining rings to make riveted mail. These particular ones are #55 rings available from Arcon Wire & Steel of Chicago, Illinois

Figure 26 6. The rod is inserted into a hole or mandrel (there are many designs available on the Internet, and many of them will work well) The drill is then used to slowly coil the wire around the rod, making a spring

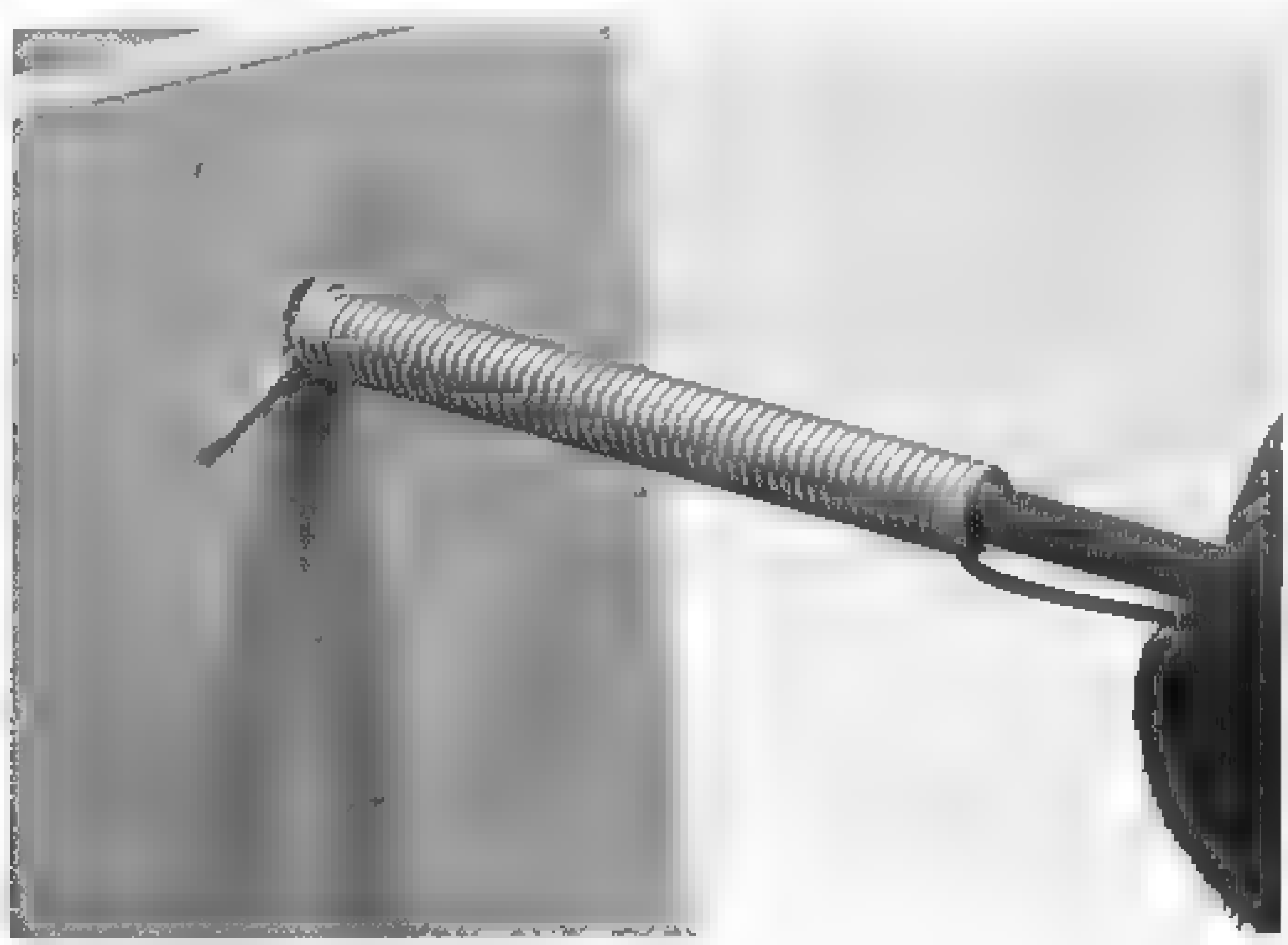


Figure 26.7. Whether done by hand or with the assistance of an electric drill, smooth coils or springs are the result These coils are cut apart, usually with wire cutters or sometimes with cutoff wheels.

solution with the same leather you intend to use for the project.

Personally, I would use the baking techniques for the construction of vambraces and rerebraces because the tooling would be valuable and I would hate to lose it in the boiling process if done either in water or wax. For couters, poleyns, cuisses, spaulders, and breastplates I would likely use the boiling water technique, as the extra amount of hardness would be valuable. In some cases, coating these pieces with wax or using the wax immersion technique also seems appropriate.

Soaking in Hot Water

Mr. Reed goes into great detail in his important work *Ancient Skins, Parchments and Leathers* discussing the chemical changes on vegetable-tanned leather when heat is applied. When leather is simply soaked in water at room temperature, it will dry and stiffen some. The hotter the water up to boiling, the harder the leather.

Most reenactors seem to have had good luck with water that is just a little too hot to the touch for comfort. The leather is left in the water until it has been completely permeated —maybe five minutes—and then removed and tacked, sewn, or clamped onto the form.

It is important that the leather not be "baked" to the point where it starts to crinkle. If this occurs it must be kept warm and stretched/hammered back into shape.

An alternative to pressing the piece down over the form is to immerse the whole form in the water. To make fitted greaves, I first sculpted a pair in steel, painted them with metal primer and a brush-on enamel, and then affixed the leather piece using bolts. The entire assembly was then dipped into hot water and soaked, lifted out, and the leather worked down over the form. This works well with any relatively shallow shape. For deeper shapes the form must be more solid, and some measure of hammering using a heavy rawhide may be in order.

Baking Technique

Another common technique, advocated by both Reed and Waterer, is to first soak the wet leather, place it around the form, and subject it to heat. The recommended temperatures vary from 122°F (50°C) to 167°F (75° C). The temperature seems to determine the amount of hardness, but too much heat or baking it for too long will cause the leather to shrivel up and lose its shape.

A big advantage of the baked or hot water techniques is that the leather doesn't malform appreciably, and it doesn't shrink as it does when the boiling techniques are used. This allows for the decoration to be embossed or incised before the heating process.[12]

To use the baking technique, vegetable-tanned leather is first soaked thoroughly in water (cold or warm), any desired tooling added, and then baked in a conventional oven. Care must be taken that the heat not go too much over 165–167°F or else the leather will shrivel and begin to shrink. It will also darken, so any decorative work should take this behavior into account as well.

Baked leather is not as hard as leather that has been hardened in boiling water or impregnated with wax, but it is a simple technique that can be employed with good results by any novice combatant or armourer.

Immersion in Boiling Water

Although both Reed and Waterer do not recommend boiling, as it can easily break down the leather's resilient qualities, two things speak in favor of it. The first is the name itself: *cuir boille*, literally "boiled leather." Second, experimentation by qualified artists and reenactors has yielded excellent results provided that the immersion time is strictly controlled. Boiling to a point just short of where the leather begins to shrivel fully polymerizes it and yields a very strong, light substance.

The boiling technique—while producing leather of superior hardness—is more difficult than either of the previous two techniques and should be attempted with all due respect for the danger of boiling water and the experimentation likely necessary to get the process down.

David Friedman has worked extensively with boiled leather from the reenactment point

Chapter 29

Armour in the 14th Century

Prior to the 14th century, medieval armourers relied primarily on mail to defend the knights in war and tournament. Mail was relatively easy to produce, did not require large sheets of iron, and provided a relatively light defense capable of turning a blade. It could be produced locally and at a low cost. During the First Crusade the casque gave way to the fully enclosed great helm, which better defended the face against the onslaught of Saracen arrows. A heraldic surcoat, emblazoned shield, and elaborate helmet dressing were adopted to identify the knight, ever after a key element in the building of chivalric renown.

Late in the 13th century, armourers experimented with the reinforcement of mail defenses, usually in the form of coat of plate body defenses. According to the fashion of the day these defenses were generally worn under the surcoat and thus are difficult to study as effigies; likewise, other funerary monuments from the time do not reveal what was worn underneath the outer garments.

The 14th century has been labeled "transitional" because during the period, armourers experimented enthusiastically with various forms of rigid defense, at first using it to augment the familiar mail and later to replace it completely.[2] They worked in a variety of materials,

Opposite page: Figure 29.1. The famous transitional armour from the Churburg Armoury represents the earliest complete harness for the 14th century Commissioned between 1360 and 1390, it is beautifully adorned with latten borders bearing the inscription "Autem Transiens per Medium Illorum bat" (Luke 4:30—"but Jesus passing through the midst of them, went his way"). Because of the scarcity of transitional armour generally and the beauty of this harness in particular, it has inspired many modern reenactors and armourers to adopt similar elements for competitive harness."

Figure 29.3. This armoured combatant represents a knight from the second quarter of the 14th century. He is armed with a moderately pointed bascinet, a coat of plates with chains affixing the sword and helm to his harness, and early plate arm and leg defenses, all executed by Peter Fuller

including wrought iron, latten, leather, cloth, and even whalebone, to work out the problems posed by substituting rigid materials for mail, and development of the knight's harness progressed at a rapid pace. Toward the end of the century and into the following one, updates to armour technology took place in increasingly compressed cycles. By 1400 most of the techniques for articulating a harness in plate were known and practiced, at least in the leading centers of Italy and Germany.

For the purposes of this book, I have chosen projects almost exclusively on armour of the transition. First, the auxiliary nature of the plate defenses for most of the century places transitional armour within the reach of the novice or intermediate armourer. Second, by following the development of plate armour through the historical track and learning the techniques as they were assimilated in medieval Europe, the temptation to "leap ahead" is reduced, which will result—I hope—in more time being spent on learning and perfecting the foundation techniques rather than trying for pieces that are much too difficult. Third, transitional armour is rich in color and material, so deficits in technique can be covered to good effect with the addition of latten, colorful cloth trappings, and fine dress accessories. Fourth, transitional armour is perhaps the best selection for béhourd reenactors, the most likely source of clients for armourers at this level. The period offers the combatant a light, competitive defense that is adaptive enough to allow a spectrum of individual expression within the constraints of historical accuracy.

CHARACTERIZING ARMOUR OF THE 14TH CENTURY

As in art, each period in the history of armour has characteristic elements of style

Figure 29.4. Armoured knights pictured in the late 14th century Grandes Chroniques de France, a beautifully illuminated history written during the Hundred Years War. Note especially the mixture of plate, mail, and cloth defenses. The events which this chronicle depicted were two decades in the past, so the armour is not contemporary with the events portrayed—in this case the Battle of Poitiers. (Photo courtesy the British Library.)

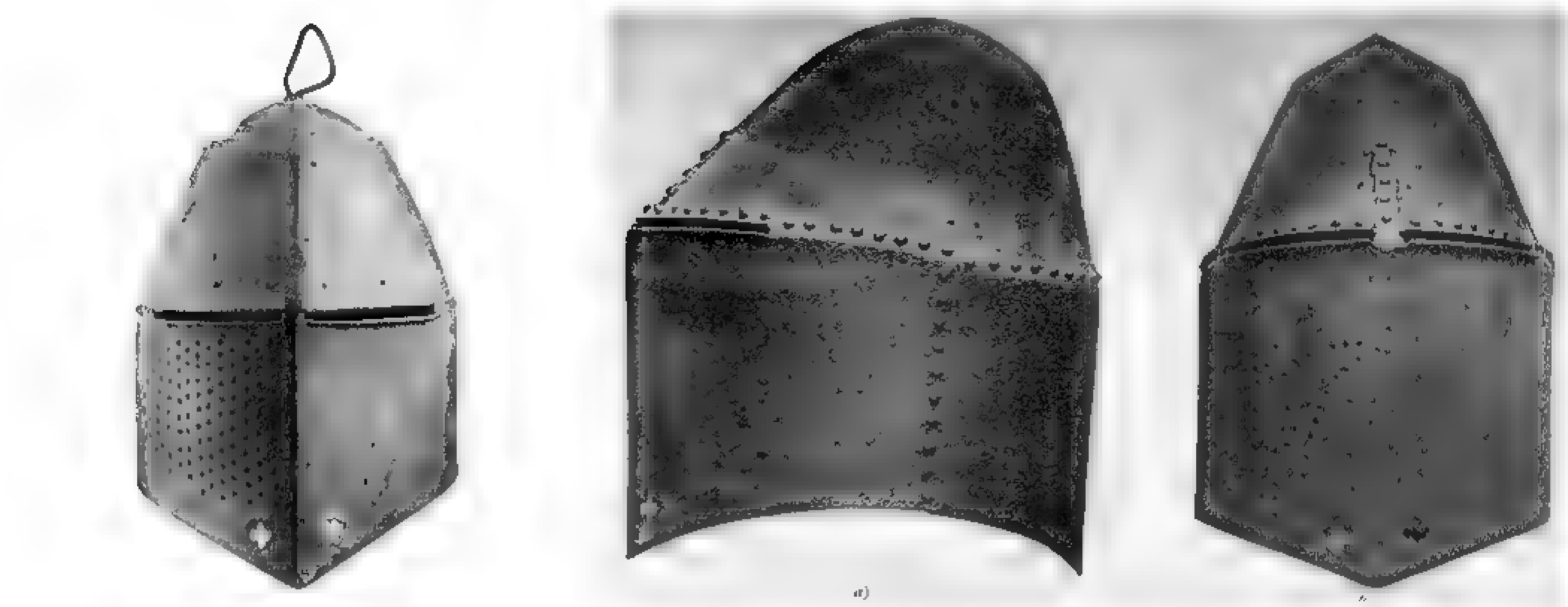
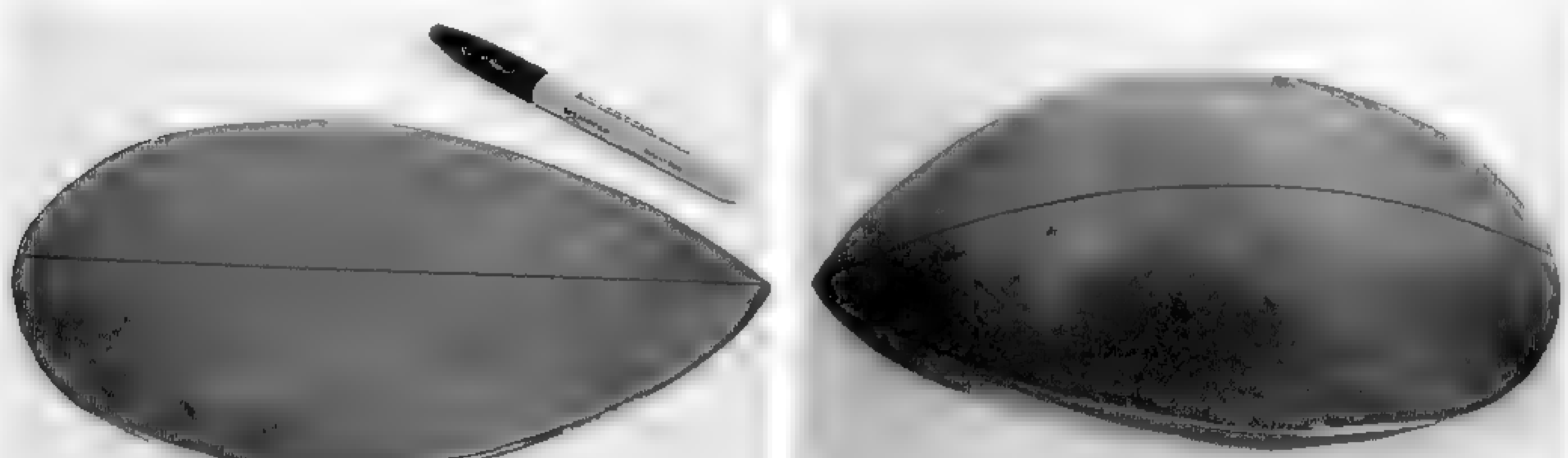


Figure 30.17 This spectacular great helm from the Royal Armouries (left) shares much in common with two other examples, the so-called Pembridge helmet and the funerary helmet of the Black Prince at Canterbury Cathedral (right). (Photo of great helmet © Board of Trustees of the Royal Armouries, IV.600. Black Prince helmet photographs are reproduced from Sir Guy Laking's A Record of European Armour and Arms.)



a b

Figure 30.18

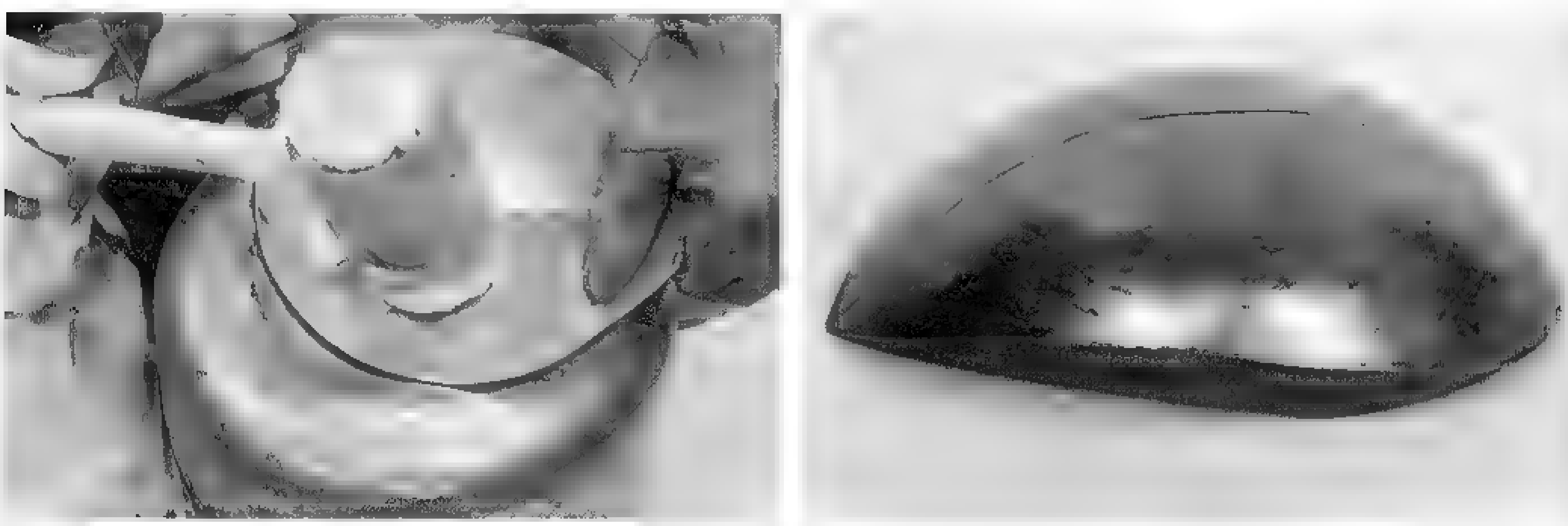


Figure 30.19

The profile and frontal view should be drafted onto a piece of paper or cardboard, appropriately scaled to the final dimensions (30.36).

The general shape of a bascinet skull is similar to a football with a cut-out for the face opening. Early in the century the bascinet was more egg-shaped, the point gradually evolving into the high-pointed fashion favored in France at the end of the century. Medium-point bascinets, such as the one created here, were popular from the middle of the 14th century until early in the 15th. After 1380 or so, especially in France, the point was often swept broadly back, while earlier in the century it was also swept back, but the point was subtle and the helmet generally more rounded.

Tracing and Cutting the Skull Halves

First the pattern is traced onto a piece of 12 gauge steel. Remember that it may be necessary to reset the shear for the heavier steel since 12 gauge is normally used only for helmets.

Cut the helmet skull on the shear and deburr it. Be careful to make a smooth, flowing cut to the inside of the line since an error of 1/8 inch on either side can yield a 1/4 inch gap in the final product. Final sanding of the edges will wait until the skull halves are being matched, but the pieces should be deburred to reduce the chance of injury during the forming phase.

Before anything else is done, the pieces should be laid out in mirror images and each one marked with a permanent marker to insure that you don't make two right (or left) halves.

Lay out dishing guides in permanent marker, lead, or chalk based on the shape drafted for the circumference pattern. Oval heads will require less doming over these points; round heads actually require a bit more, as do the more egg-shaped bascinets of early in the century. German "oggival" bascinets (see fig. 30.1) also require more doming (especially in zone 1) and must be marked accordingly. Most of the doming will focus on points #1 front and back (30.37).

Doming the Skull Halves

First, lay the pieces out and work them into a large, shallow dish (30.38). Work from the edges, spiraling in toward the center. Use a large, heavy rawhide hammer of between 3 and

Figure 30.37. In doming the bascinet, the different areas of the skull require different treatments at different steps in the forming process to achieve the desired shape. Zone 1 (front and back). regions of initial deep doming. Zone 2: transition area, where the points at zones are feathered together. Zone 6. the lower edge, the transition between the domed sections and the relatively flat skirt that will be attached later. Zone 7: the area around the visor Zone 3: the leading edge, a welded joint that will comprise the median ridge. Zone 4. the trailing edge, a welded joint that will usually have no ridge

Figure 30.38. The shallow dish and a heavy rawhide are preferred for 12 gauge steel, since the heavy metal will resist any lighter hammer. The rawhide domes the metal without scarring the surface or adding hammer marks. Medieval armourers might have done work like this with wooden mallets, but little proof of this has come to light

shape as the breastplate extends around the body. Notice especially the obvious similarity to the Wisby #7 shown earlier in the chapter—both of the defenses form loose barrels to defend the body's trunk

Each of the wrap plates must be domed using the same dish and rawhide hammer. They should fit to the previous plate with approximately 3/4 inch of overlap, producing a snug yet continuous arc around the body. On the last plate—the one defending the kidney—the edge should be flattened so that the plate sits snugly against the back, which is relatively flat. Once all the plates have been fit, they can be sanded in preparation for the rolling of the edges.

The top and bottom edge of each plate will be rolled to the outside (31.25)—this is a lot of edge rolling, roughly 8 to 10 inches for the average piece. Take your time and don't rush. The rolls should be small and round rather than flat. Be particularly careful around the arm hole, a difficult roll since the arc is tight. When the rolls are completed the pieces are tested for fit (some flattening often accompanies the rolling process), sanded, and polished.

The next challenge is to place holes for the leather binding (31.26). First, place 5/32 inch holes on the centerplate roughly 3 inches apart and 2 1/2 inches from the edge. This should be done by test-fitting the second plates to insure sufficient freedom of movement. The holes are drilled from the inside to leave flash on the outside. The flash is cleaned and the hole countersunk using a 1/4 inch drill bit.

Each of the other plates are punched or drilled for a 5/32 inch arming nail. Three holes will be used to attach each plate, except for the second plate which has more on the longer section.

Figure 31 22. Finishing the neck opening. On the original the roll is left curled

Figure 31.23. Brass trim.

2 Thordeman, Bengt. *Armour from the Battle of Wisby*. 1939. Vol. I pp. 345–9. Add to this that the #6 harness is also mounted in this fashion and I don't think the evidence is strong enough to rule out his reconstruction, his analysis being based on compelling evidence in the distribution of the original plates and the attachment points for hardware. However, field trials with this design have not proven as workable as the more common design I present here.

These things aside, a standard legharness of the period suffices well for most situations.

References and Anachronisms

Like other 14th century armoured elements, references for plate cuisses are scant. The Royal Armouries' cuisses (34.1) are one of only two examples the author is aware of, the other being the Chartres harness, which is also blessed with a greave and sabaton.

Because of this paucity, monumental brasses are called upon to help with the generic harness from the period. Most well-developed harnesses late in the century were fitted with a moderately sized poleyn, two lames—one above and one below—a demi-greave that attached to a full or frontal greave, and a matching cuisse that attached directly to the upper lame. Some cuisses were fitted with a wrap plate extending the defense toward the back of the thigh, but most simply defended the front. At the end of the century a few references depict an additional plate attached at the top of the cuisse, foreshadowing Italian and German tendencies throughout the next century.

Some of the cuisses were modeled—as is the one in the Royal Armouries—while others appear to have been simply curled. Both types tend to feature a strong central ridge that continues into the lames, poleyn, and greave, the whole defined by a sharp line that is a distinctive element of style throughout the period. This arch shape is useful in creating a crisp execution. Using these originals plus the Black Prince's effigy at Canterbury, we should be able to project how a standard harness may have worked.

Because the harness depicted in this chapter was to be worn with pieces suggested by the Churburg #13 harness (which no longer has the legharness), brass was added to the poleyn and the cuisse shaped like the Royal Armouries to match the vambraces done in Chapter 32. The client desired no greaves, but I demonstrate a modern shortcut for the creation of frontal greaves that I hope will bring some form of greave within reach of the intermediate armourer. I can find no evidence that medieval greaves were made with the constructed technique shown here.

Greaves are difficult because they feature complex, asymmetrical curves and must be raised on a difficult set of axis. The portion of metal around the ankle must be compressed into the shape of an ankle, no easy task even for skilled armourers, many of whom pride themselves on a well-executed pair of case-fitted (fully enclosed) greaves.

The poleyn in this example is raised rather than welded, although novice armourers might want to consider doing it in two pieces with a seam down the center. Do not attempt to dome the poleyn completely into a deep dish or

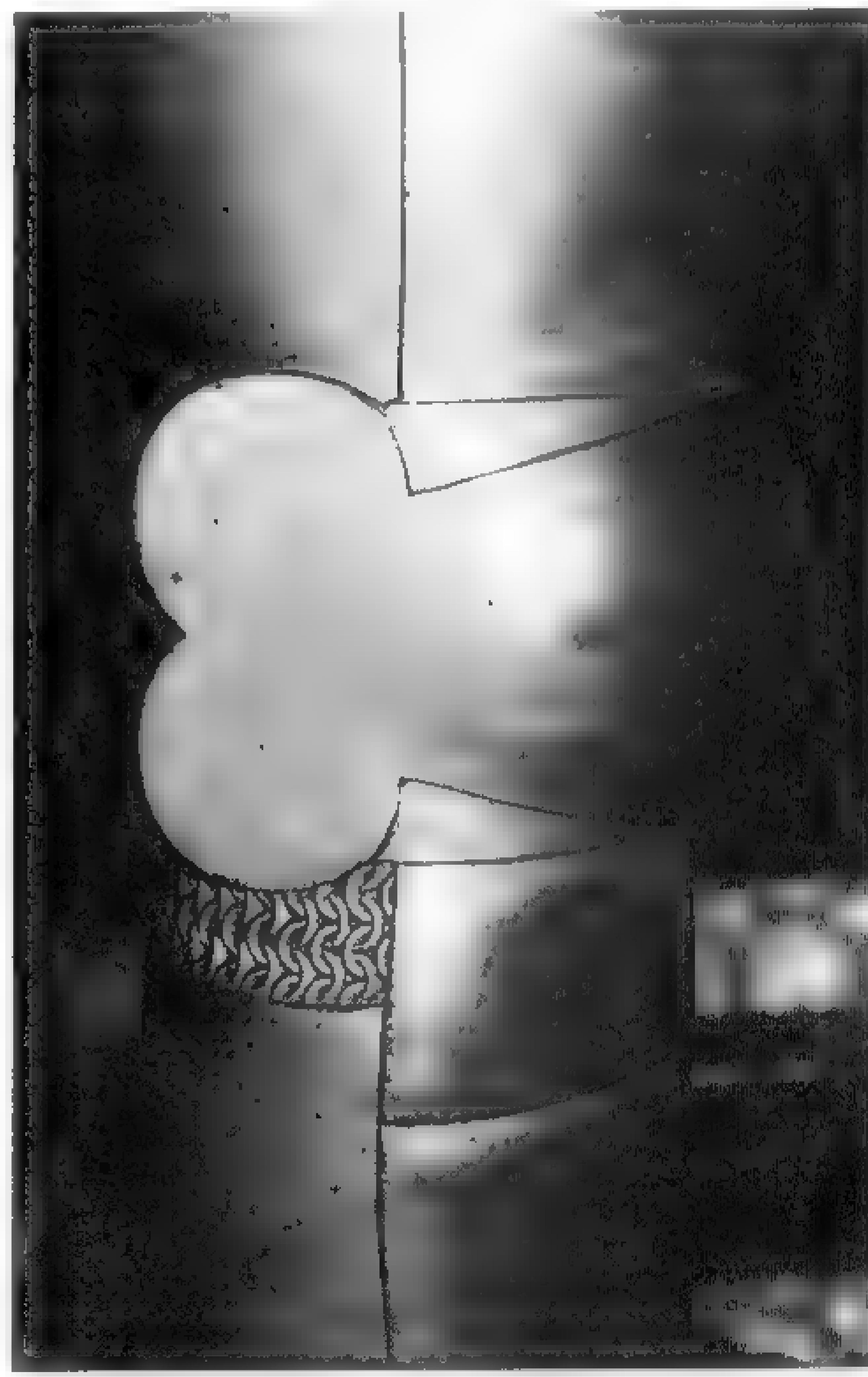


Figure 34.2. A photograph taken from the Black Prince effigy at Canterbury. The Prince is shown with what amounts to textbook "standard" for leg defense during the 14th century: a single, domed poleyn of moderate depth, two lames, a demi-greave, cuisse, and greave. Annoyingly, the rivets were not detailed by the original sculptor.

the result will be too thin to use without successful heat-treating (which in turn requires you to start with medium- or high-carbon steels). I recommend that novice armourers use a straight cuisse for their first several attempts, as the shaped cuisse, while pleasant, does not hold up to punishment as well as a straight cuisse in mild steel.

The anachronisms on the cuisse and joint are few. The cuisse is worked from the inside, curled on an anvil horn as many pieces seem to have been according to the evidence available by examining the cuisse interiors from the 15th and 16th centuries.

CREATING THE LEGHARNESS

A working drawing and set of templates are handy for creating the legharness, particularly if a greave is required. Take careful

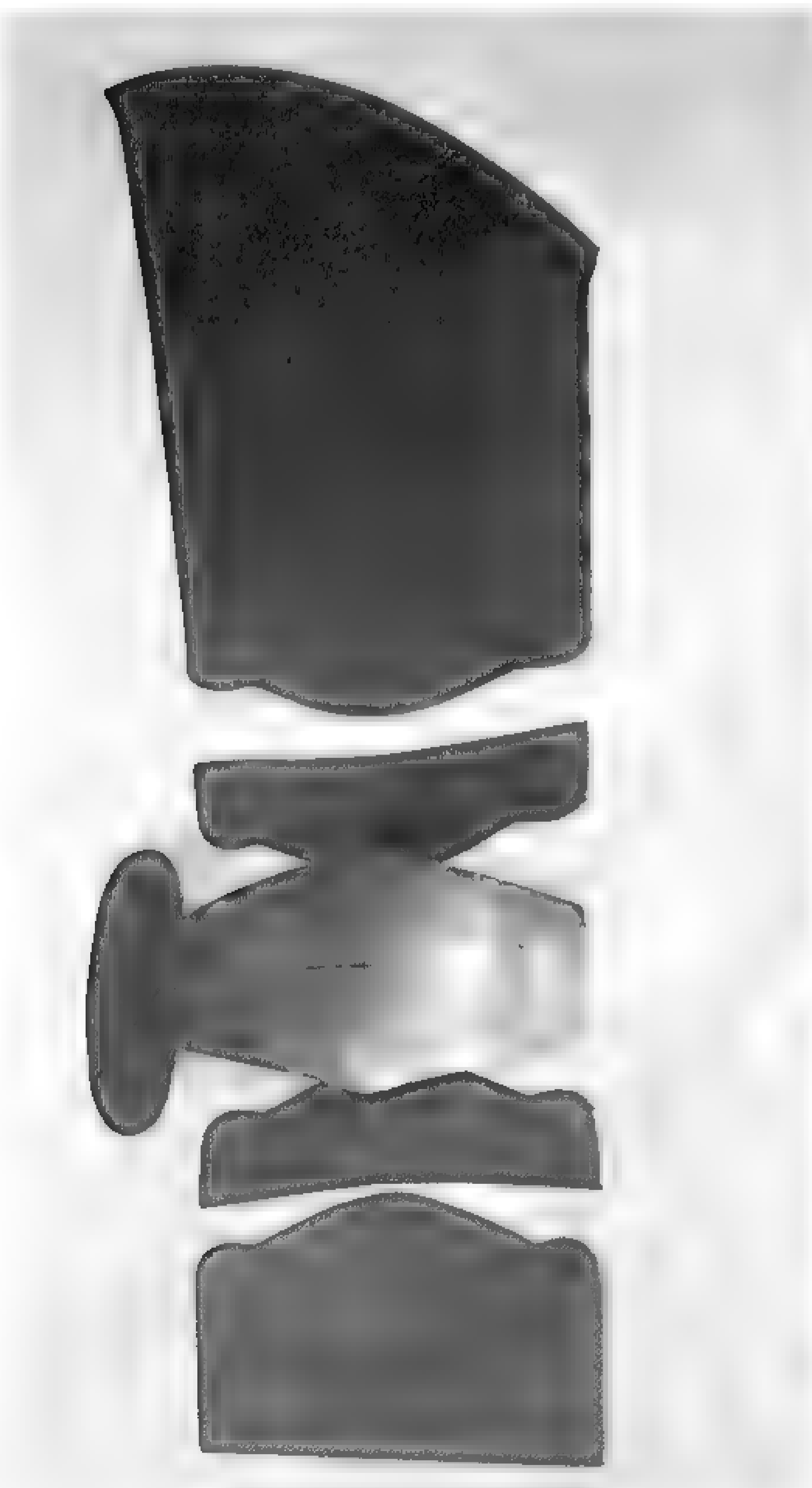


Figure 34 3 Legharness flat

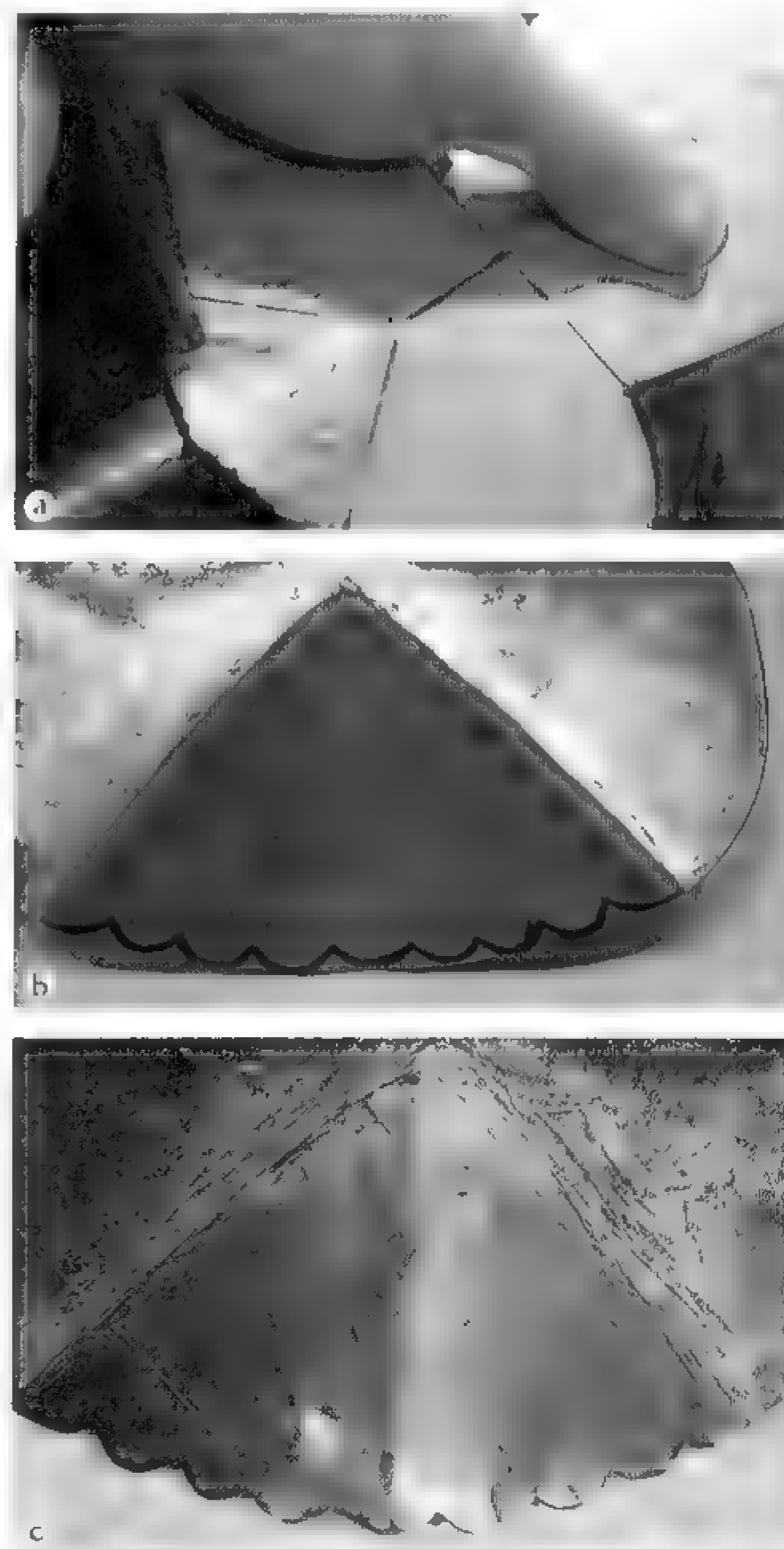


Figure 34 4 Embossing the wing

measurements, particularly of the muscles above the knee as the combatant kneels to create the basic parameters controlling the size of the poleyn, around which the rest of the harness is built.

Forming the Poleyn

Because the poleyn needs to be sufficiently deep to allow for bending of the knee with only two lames, it should be cut from 14 gauge mild steel. If the harness is to be done in spring, then 16 gauge will be enough.

Work begins on the wing. There are many styles of wing available for the 14th century, from the "double round" seen in the Black Prince effigy (34.2) to the fully embossed Churburg #13 style. Both the Black Prince and the Chartres poleyn wings are flat, although it is very possible that brass adornments might have been added as a protective measure and to enhance the otherwise drab surface.

An alternative—and very easy—treatment for the wing is simply to crease it with a long, dull chisel. I recommend this for novice armourers as it produces a very clean, quick treatment. For the purposes of this harness, however, the wing must match the Churburg #13-style elbows so a similar embossing will be attempted.

Before any work begins, a centerline is marked down the center of both sides of the poleyn, both in the horizontal and vertical planes, to insure that the forming remains even (34.3). Some armourers have even taken to placing a grid on the surface to help with symmetry, though I have never tried this.

Mark the wing with permanent markers to place the wing embossing. As with the couter treatment done in Chapter 32, a narrow-faced raising hammer is used from the back of the wing to pull the metal up and into a neat triangular area (33.4a). Once this is even, the area is heavily bouged from the back with a very slightly domed hammer and the crease sharpened. Optionally, the edge can be marked for grinding the scallops to match the Churburg arm harness (34.4b–c). The rest of the wing is quickly worked with the large, slightly domed-faced hammer, simultaneously smoothing and hardening it. Do both poleyns together to insure symmetry rather than doing one and trying to match it later.

Once the wing is complete, lightly dome the poleyn into a shallow dish in preparation for the raising process (34.5). Work cautiously into a medium-depth dish, providing just enough dome from which to start. You should have something that resembles a rounded dome, evenly dished but bearing little resemblance to the final shape.

The next step is to achieve the required depth through raising. Working over a ball stake or raising T-stake, work in passes around the horn, being conscious of the desired shape (34.6a). The poleyn is not round strictly speaking, so refinement of the eye grows increasingly important as the subtle shapes of the originals become evident. Capturing the medieval tone is a matter of capturing these subtleties, and in raising such a piece it is easier than with welding, which is functional but dull.

One quick pass is sufficient to provide the appropriate depth. Working from the center in circular passes around the piece (34.6b–h), the metal is compressed downward. As you approach the wing and inside edge of the knee, the metal must be pushed down aggressively, as it builds resistance at this point. Work evenly with overlapping hammer blows for the cleanest results, bouging and planishing the entire poleyn before setting the crease. When finished, the poleyn should have the arch-shaped profile when seen from the

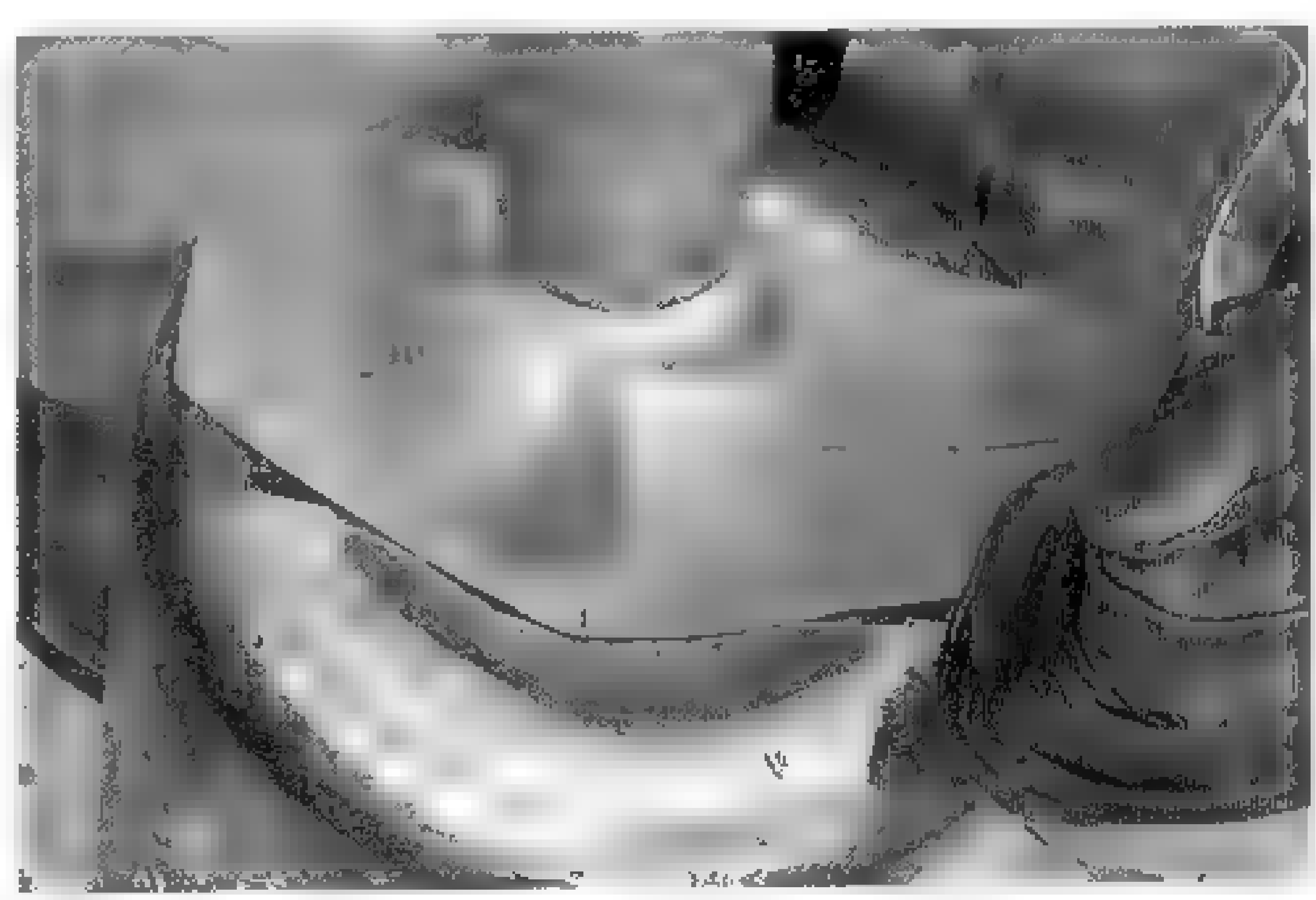


Figure 34 5 Doming the poleyn

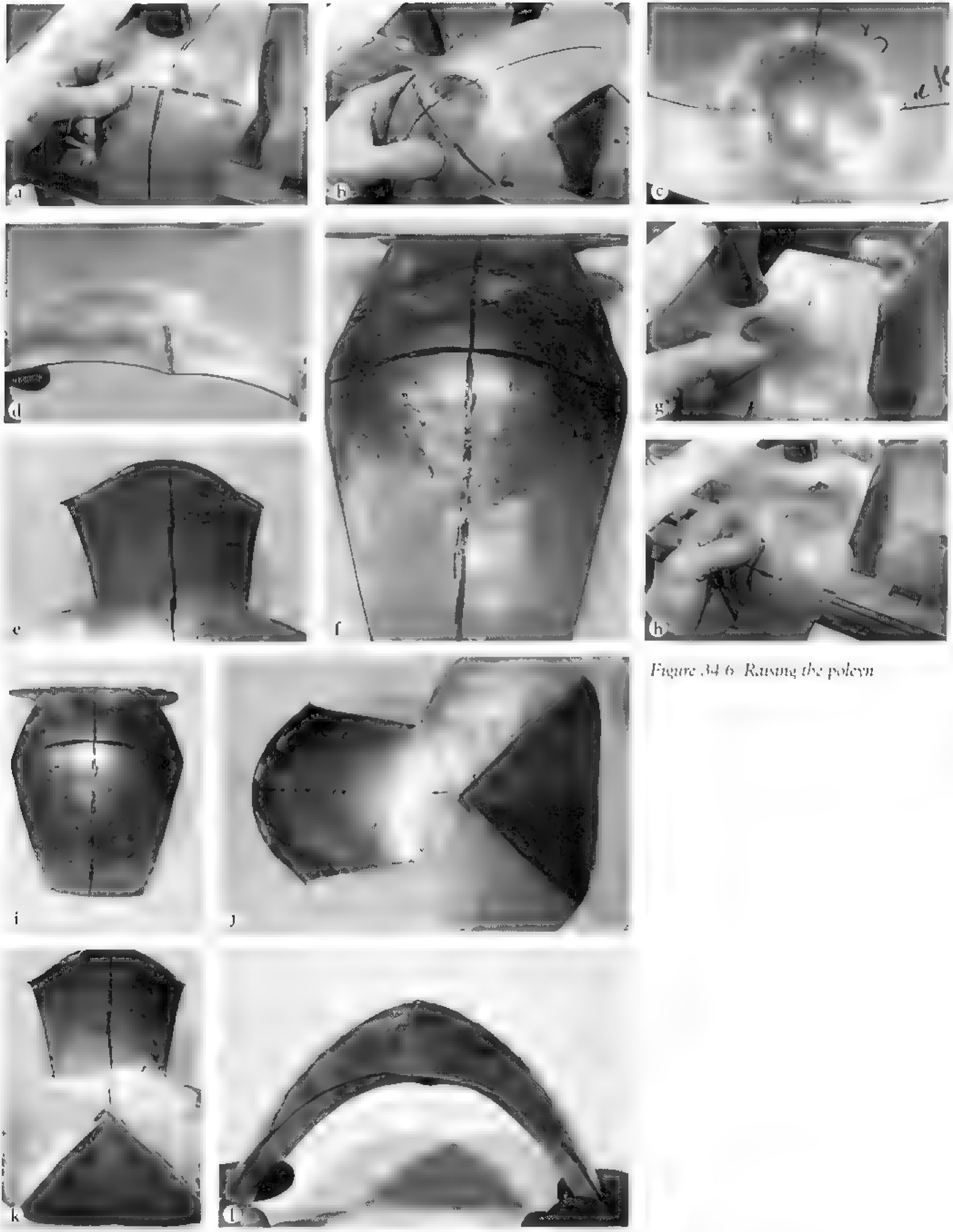


Figure 34.6 Raising the poleyn

top (34.6l) and be deep enough to provide movement for the knee (34.6j–k). Lay a crease, being careful to follow the centerline and to retain the original depth sanding the poleyn (34.7a–b). When both are complete they can be sanded and roughly polished, or the finishing can be left until the end. In this case a brass border was added to match the rest of the harness (34.7c–d, see Chapter 23 for additional photographs).

Next, the lames are quickly domed and curled to match the poleyns. After cutting, flatten them and remove the troublesome burrs that frequently occur (34.8a). They are curled into a large, shallow dish (34.8b) and shaped (34.8c) to match the poleyn (34.8d). When they are close, the articulation points are dished and planished (34.8e) and the lame roughly met to the poleyn, where they will be articulated using the shell techniques shown in Chapter 20. Once they have been articulated to the poleyn (explained below), they can be creased and sanded.

The techniques to form the demi-greaves—which in this case are relatively straight instead of being shaped—can be used to produce cuisses, save that there will be a roll at the top edge. The steps are the same but on a larger scale and without any initial doming.

Since the demi-greaves are relatively narrow, the crease can be started by hand (34.9a). Next the entire length of the crease is worked quickly with the hammer to set it in place (34.9b). Using a light rawhide, preliminary curling is done over a horn (34.9c). Working from the inside, the areas to either side of the crease are then pressed downward (34.9d). The crease is sharpened carefully with a fluting hammer (34.9e). Finally, the entire length of the piece is hammer-hardened, an unnecessary detail if it is made of spring, though it does present the opportunity when working over a raising stake to add subtle—and more pleasing—lines (34.9g). A quick pass along the outer edge will regularize the depressions that tend to occur from a curling operation (34.9h–i).

The articulation points are now very slightly domed, either on an anvil face or into a lead block (34.9j). When this is done and planished (34.9k), the whole greave can be sanded, polished, and any decorative material attached (34.9l). The edge of the demi-greave is rarely rolled, so a convenient 14 gauge brass border adds extra rigidity, useful for kneeling combatants who tend to deform these pieces.

Forming of the cuisse starts off similarly but is harder owing to the thicker metals and

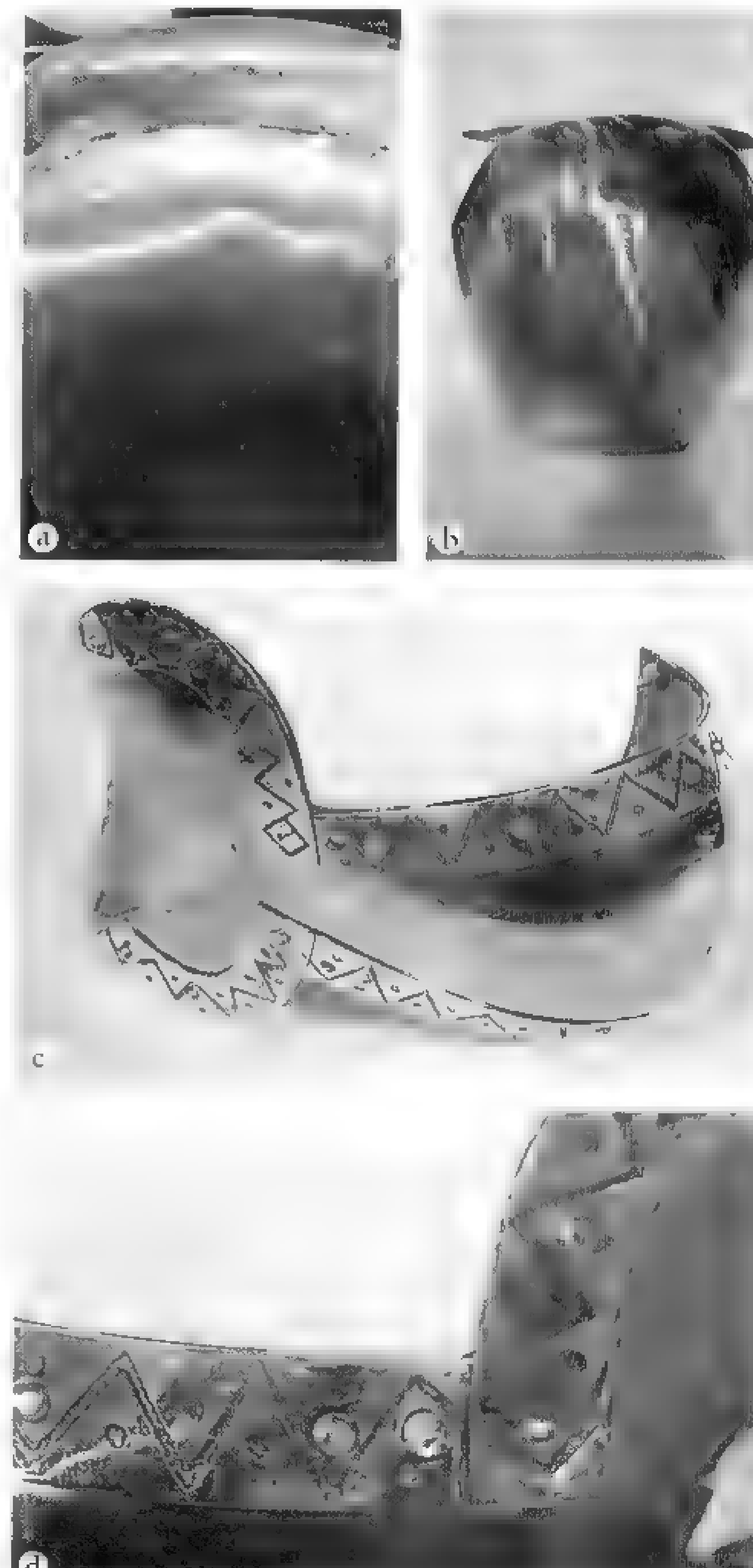


Figure 34 7. Finishing the polyens

increased surface area. I cut these pieces from 14 gauge mild steel, although this is a great place to save weight using spring steels and heat-treating.

As with the demi-greaves, the central ridge is first placed along the centerline, although it must be done with a hammer rather than by hand (34.10a). If I were doing this pair again, I would wait on setting the central ridge until after the doming was done to achieve a better profile, as the crease adds a rigidity that prevents a fully sculpted effect. If straight cuisses are preferred to the sculpted ones shown here, the inside forming can be omitted in favor of simply curling the piece and sharpening the crease.

Following the creasing the piece is curled (34.10c), this time with a heavier rawhide hammer. All the curling does in this case is achieve the general cuisse shape (34.10d); the real forming will be done from the inside using a slightly round-faced, very heavy bouging hammer (34.10e).

Starting from the edge (34.10f), even passes are made extending from side to side toward the crease (34.10g). Along the crease, a square-faced hammer is used to bouge along the entire length (34.10h–i), finishing the interior shaping.

The cuisse is now very lightly domed into a dish using a rawhide hammer (34.10j), being careful not to dent the surface. This treatment works much better if the piece is to be heat-treated, since its resistance to future malforming is greatly enhanced, but the effect is pleasing in any material.

As with the Chartres original, a bump is placed at the end of the cuisse to help with the range of motion. This bump acts as an additional lame, offering increased mobility. It's unnecessary

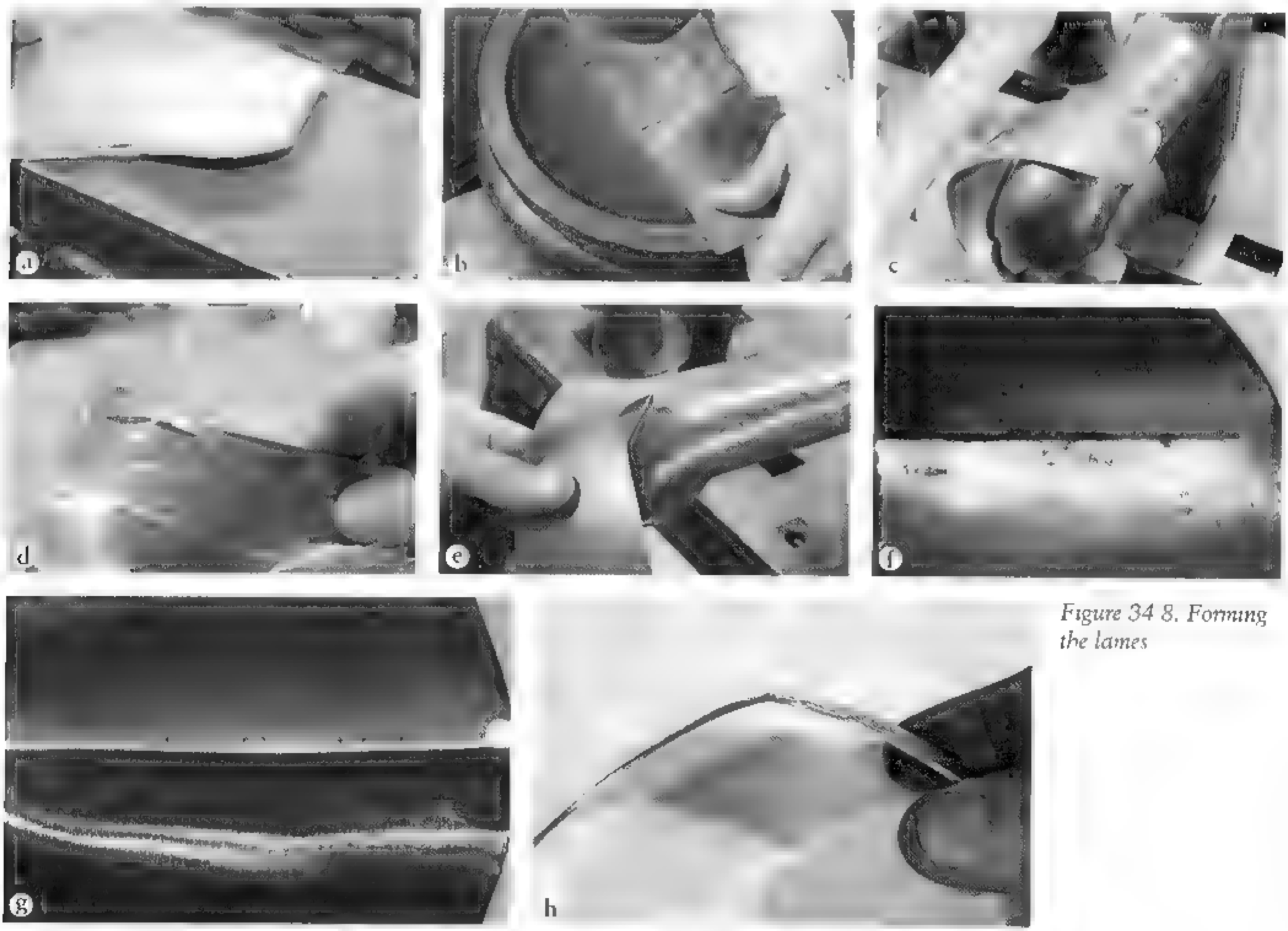


Figure 34 8. Forming the lames

but useful. Using a large ball-faced hammer, the material is pressed down into a lead block (34.10k–l) and planished (34.10m) in preparation for sanding and edge-rolling (34.10n).

Since the roll is actually done as a demonstration in Chapter 16 it won't be covered here, but it should be said that the upper roll is often quite large, using as much as 2 inches of material, tapering starting at the groin, becoming larger as it reaches the apex of the arc, and growing smaller again as it reaches the back of the cuisse (34.10o). Note that the original Churburg cuisses have no roll at all, which is less than ideal if the piece is executed in mild steel. This, combined with the central ridge and hammer-hardening, provide a degree of durability even without working in the more expensive material.

Although the shell articulation techniques used in this harness are well-covered in Chapter 20, a few words of reminder are appropriate since every harness is different.

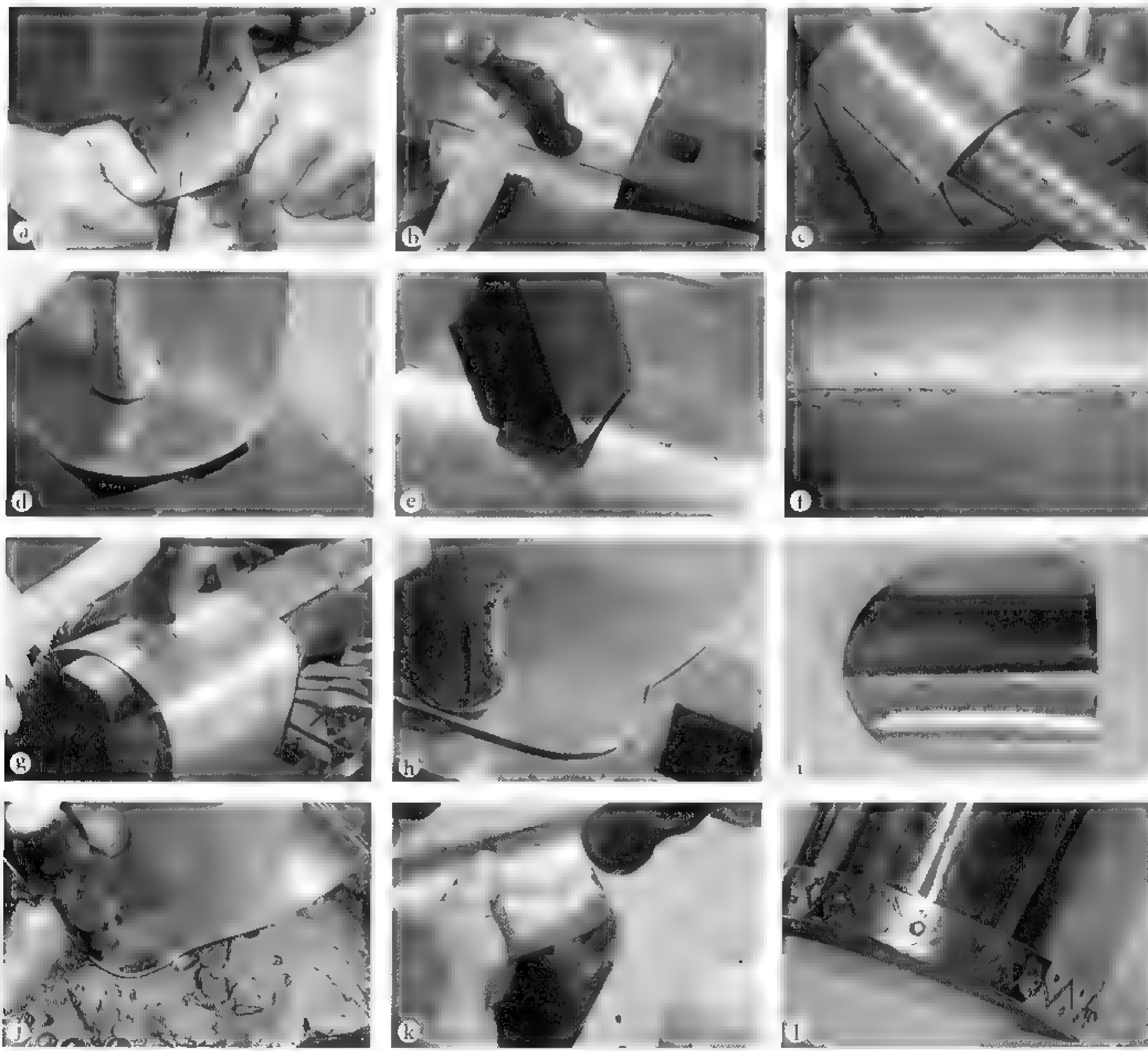


Figure 34.9 Forming the demi-greave

Figure 34 10 Forming the cuisse

First, the holes in the poleyn (34.11) must be situated so that they sit entirely within the brass border. The holes are placed as close to 180 degrees as possible such that a pencil could be run between them. This is an ideal, and the reality is generally a bit less, as it is in this case.

To start the articulation the interior hole is placed and the lame bolted in place (34.11b). A guideline is drawn at the edge of the lame at the articulation point (34.11c), the lame once more bolted to the poleyn, and arcs drawn in both the open and closed positions (34.11d) to create a guide line, in between which the hole is placed (34.11e). Testing the lames in the open (34.11f) and closed (34.11g) positions, the joint seems to function well.

Holes are now added to attach the demi-greaves and cuisses (34.11h), and the final joint is ready for assembly (34.11i). Notice the very close fit between the lames and poleyn. This is not an ideal, perfect fit, but the armourer should strive for as little gap as possible in both the open and closed positions.

I tend to attach the cuisses first, since there is a great potential for the final harness to look askew if it's not straight, though the techniques for attaching them are precisely the same as is shown for the demi-greaves above. The longer length of the cuisse helps to insure that they are attached properly (34.12a).

To fit the demi-greaves or cuisses, simply check them at both the straight (34.12b) and bent (34.12c) positions, marking candidate holes. Use care with this step since errors will insure that you have to fill the holes either through hammering (20.15) or with ugly welds.

Use extra care to insure that the demi-greaves (34.12de) and cuisses are straight, as the entire harness can be quickly and depressingly

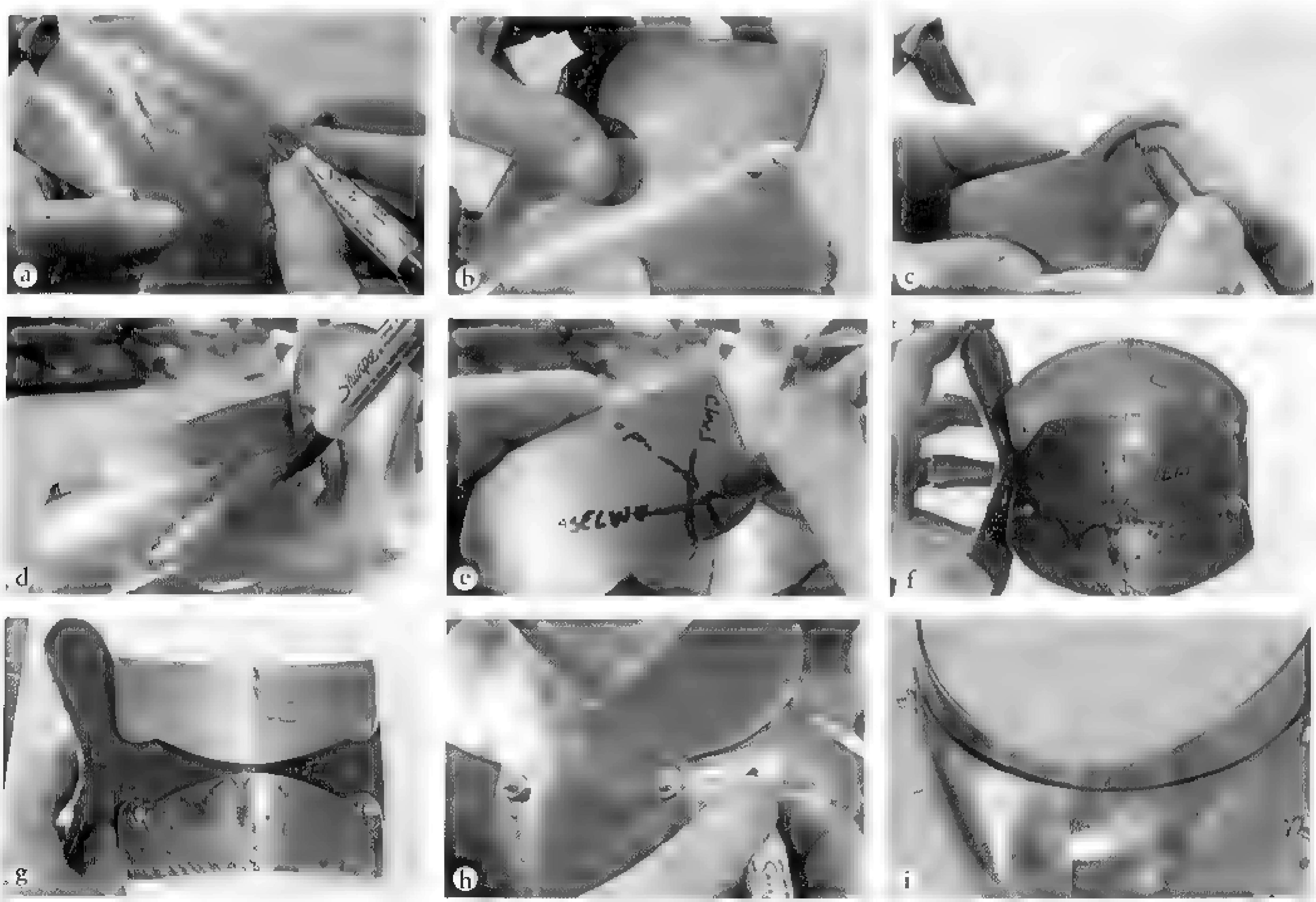


Figure 34.11 Articulation

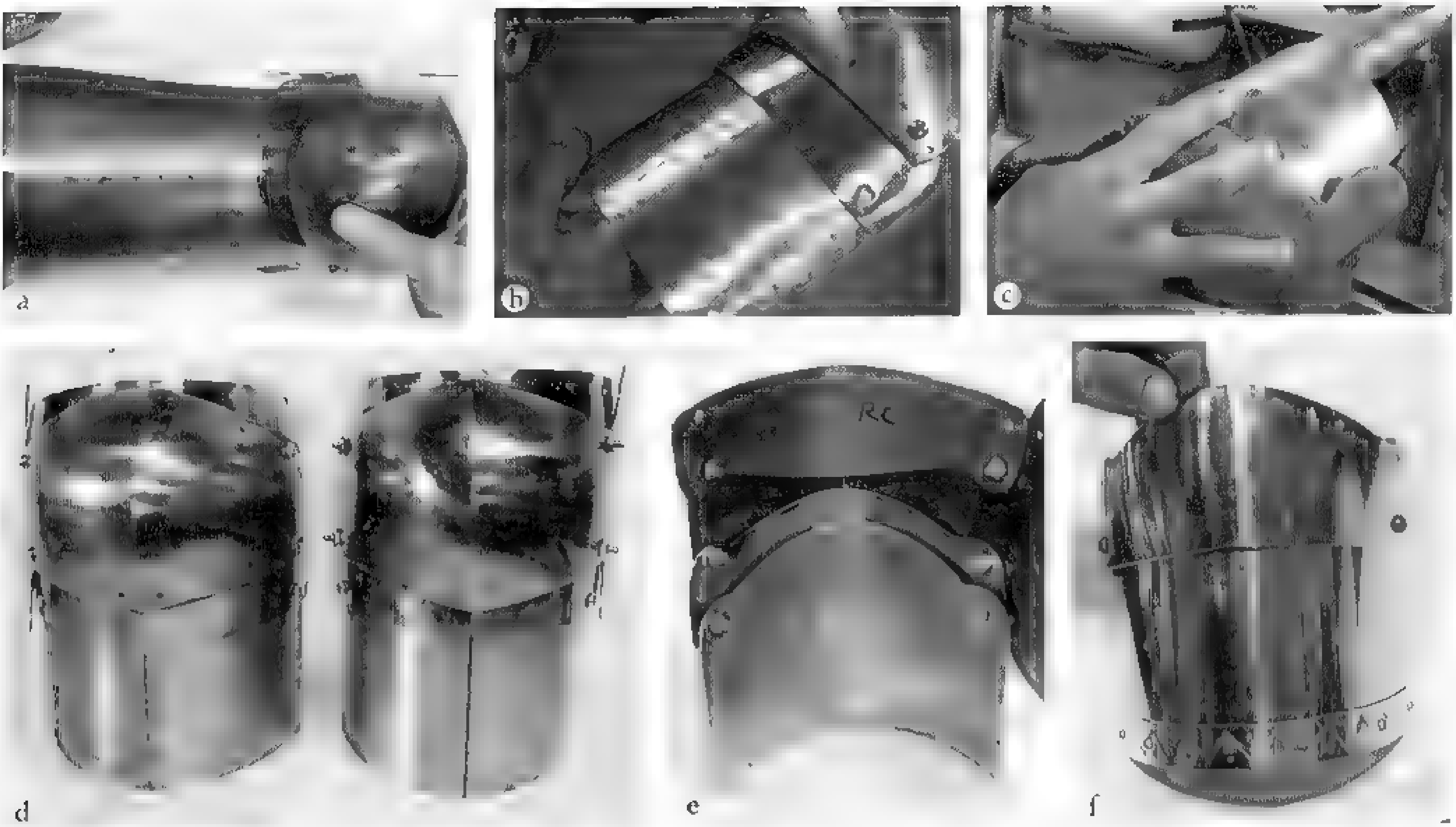


Figure 34.12 Assembly

Figure 34.13 The completed harness.

ruined at this stage. When all the pieces are fit, they can be unbolted, sanded, and polished.

To assemble the harness, start from the demi-greave, attaching it first to the appropriate lame (34.12f). Next attach the cuisse to its lame and finally the two assemblies into the poleyn. Follow the strapping guides in Chapters 20 and 25 to mount the harness. If you are careful the final assembly will be crisp and clean and will give enough range of motion to satisfy any tournament combatant (34.13).

MAKING A FRONTAL GREAVE

Although this client did not opt for greaves, they are a vastly underrated—and difficult—component of plate armour from the High Middle Ages. Given that raised greaves are so hard, I offer here an intermediate technique designed to bring greaves into the reach of more junior armourers in the hopes that it will increase the demand for greaves in a tournament setting, where they add a great deal.

Whether the greaves are to be constructed or raised, the measurements for

the lower leg are critical; tracings from the front and side are exceptionally useful, plaster casts even more so. The most important thing to consider when starting greaves is to see that they are not symmetrical but rather follow the musculature of the lower leg. An anatomy book will help the armourer to see the lines, although they have to be smoothed and worked over boots and hose and integrated with the demi-greave. Use the guide in Figure 34.15a as a starting point, but make an effort to study the many remaining greaves from the 14th and 15th centuries.

The basic strategy to reduce the time and expertise needed will be to construct the front in two pieces, relying on the weld to create the central ridge. The backs could be constructed in a similar manner, bringing the whole case-fitted greave into range.

The first step will be to dome the greaves—unequally as is shown by the guides above. This can be done into a shallow dish or on a flat anvil face. The results are quickly achieved (34.15c–d) and not too critical, since the pieces must later be planished.

Next the pieces are curled lengthwise with a medium weight rawhide hammer (34.16a). Using the natural depression of the raising stake, the convex area of the ankle can even be roughed at the same time (34.16b–c) and the roughly curled pieces quickly take shape.

Once the rawhide curling is done, a more aggressive curl is placed with a broad-faced raising hammer (34.16d–f). This work centers on the ankle

Figure 34 14 Completed frontal greave

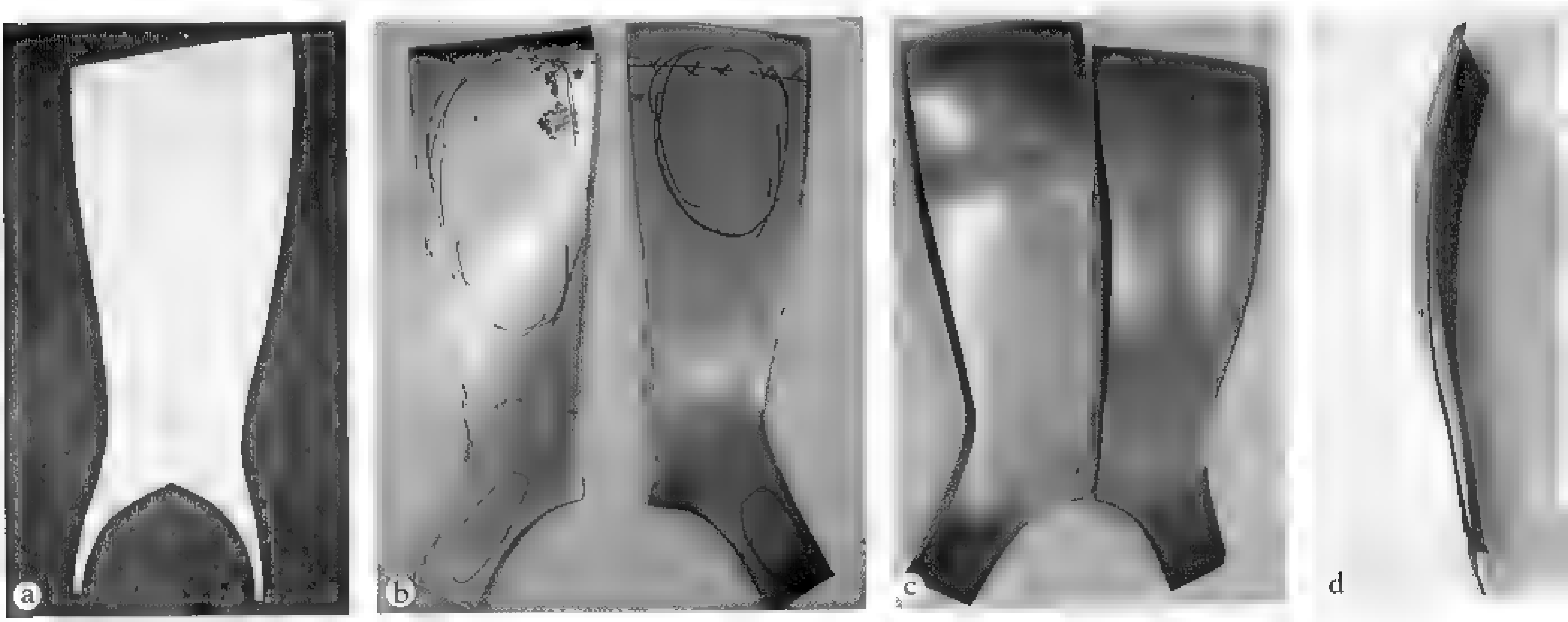


Figure 34 15 Flat and doming guides, followed by early forming steps

and, since it is done from the inside, is much easier than making similar shapes in one piece from the outside. Note that this curling should not be done blind; keep photographs around to look at during the process, working for a smooth transition between the narrow ankle and the broader domed calf (34.16g–h).

The armourer should not be too concerned about matching; the pieces will only be loosely matched along a 4 inch central point, welded, and then matched to finish, so the fit at this point is not terribly important. When both pieces have been done to this point, they should be held against the cardboard template;

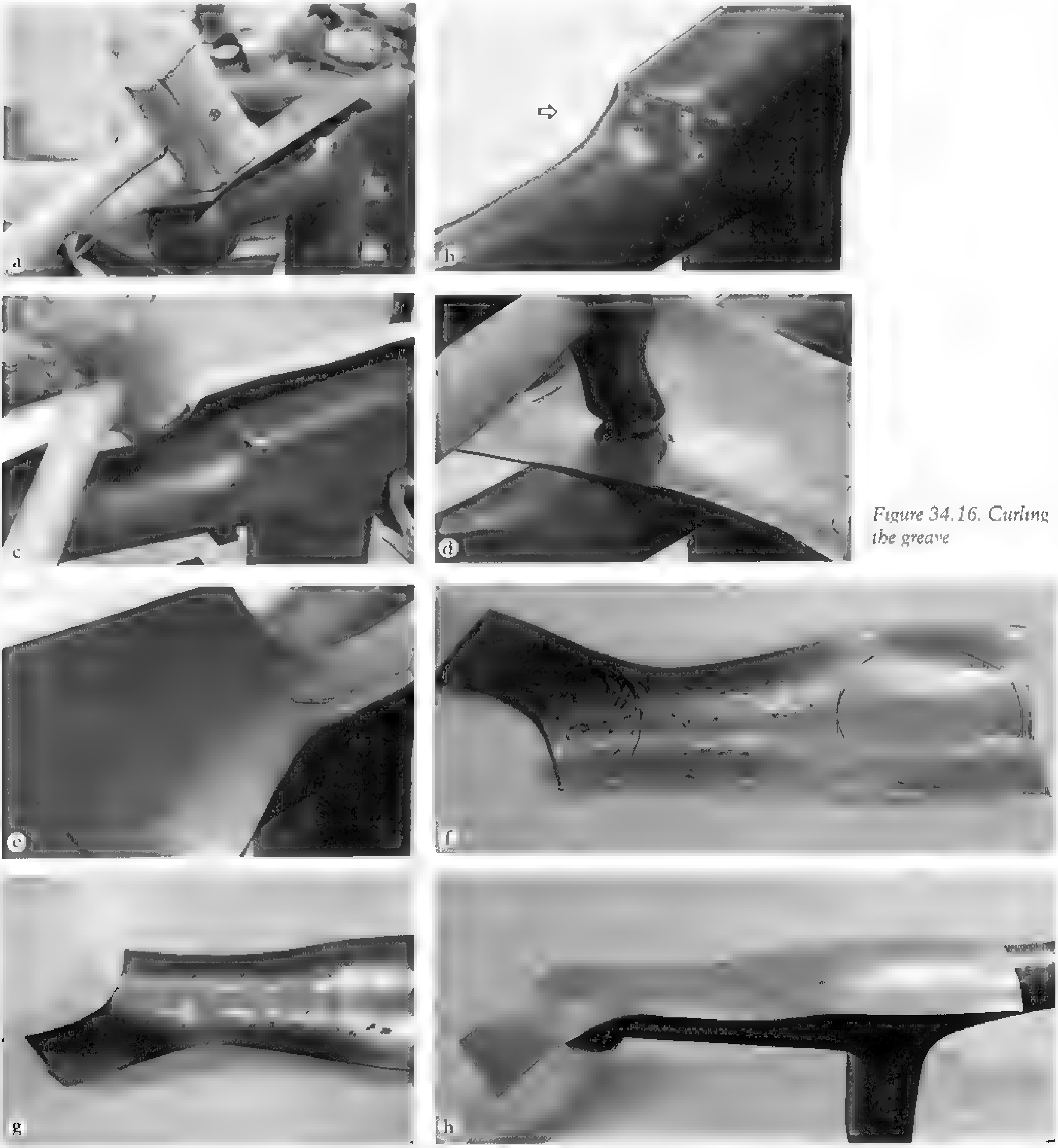


Figure 34.16. Curling the greave

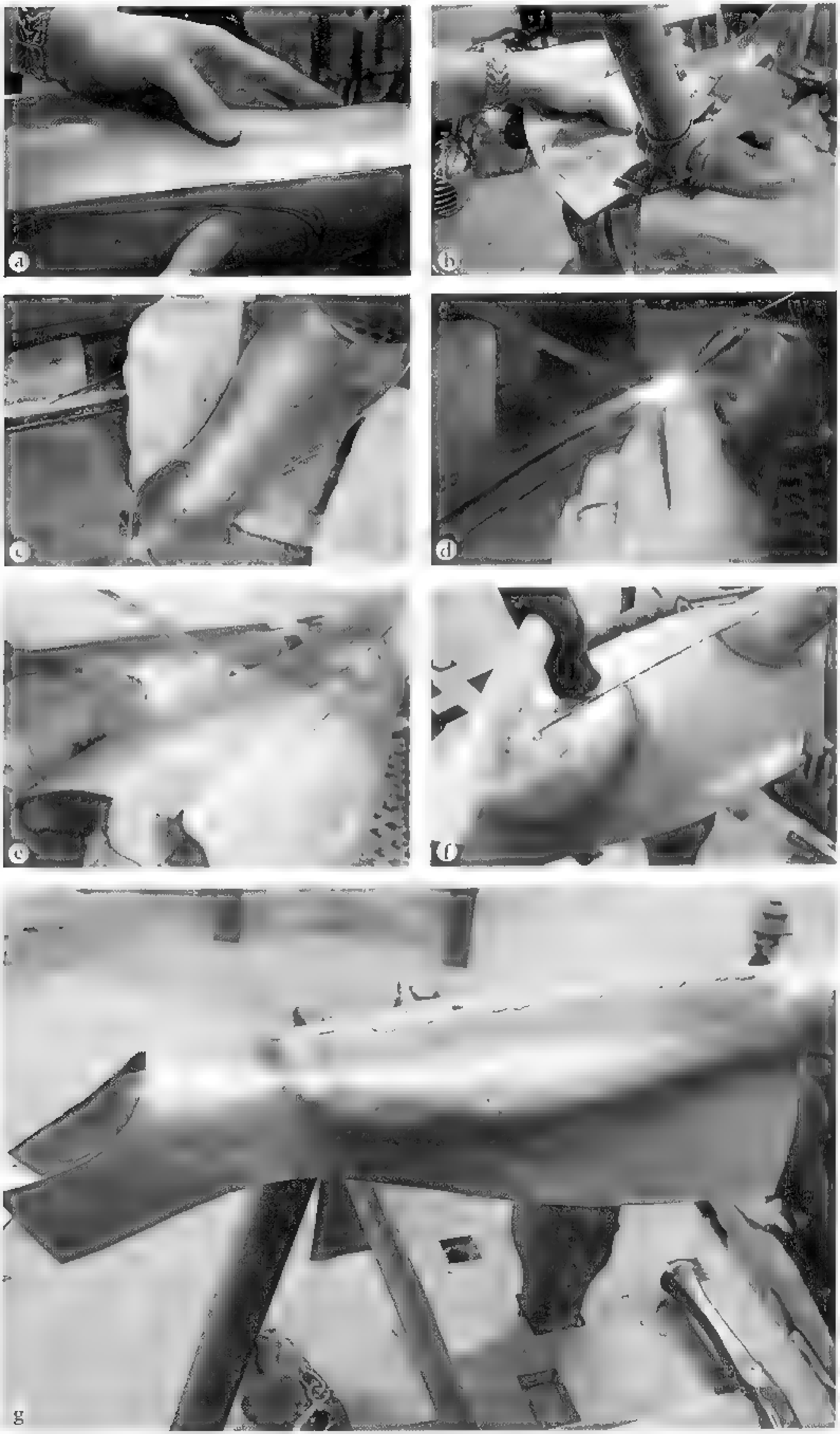


Figure 34 17. Matching and initial welding

work should continue until they approximate the original template.

Now the armourer will actually attempt to match the 4–8 inch section along the center of the front (34.17a) to accommodate the weld. Some trim will be necessary to accomplish this (34.17b), but do it slowly because it's always easy to cut again but difficult if you make a mistake and take away too much. Because the material is so thin (I started with 18 gauge), great care must be exercised and the metal should match *exactly*; otherwise thin spots will surface during grinding. For thinner greaves intended for heat-treating, the match is even more important.

Figure 34 18 Finishing the greaves

APPENDICIES

Appendix

The Company of Saint George

The author is a founding member of the oldest tournament company, the Company of Saint George (USA). Comprised of like-minded practitioners of the chivalric arts, both within the Society for Creative Anachronism (SCA) and in other reenactment organizations, the company strives to advance the skills and renown of the members through hosting of and participation in medieval feats of arms.

The Company has spawned many similar groups since its inception in 1990. It was created along the lines of the medieval monarchial orders of knighthood such as the Order of the Garter and the Order of the Star as well as the German tournament societies of the 14th and 15th centuries. This quote, taken from a 15th century charter for the Order of the Golden Fleece (c. 1430), expresses the company's purpose well:

Then hear, princes and princesses, lords, ladies, and damsels, knights and squires, the Very High, Very Excellent, and Very Puissant Prince, My Lord the Duke of Burgundy, Count of Flanders and Artois, Count Palantine of Burgundy, Count of Namur, etc., makes known to all that for the reverence of God and the maintenance of our Christian Faith, and to honour and exalt the noble order of knighthood, and also for the following three reasons: first to

do honor to knights, who for their high and noble deeds are worthy of being recommended; second, so that those who are at present still capable and strong of body and do each day the deeds pertaining to chivalry shall have cause to continue from good to better; and third, so that those knights and gentlemen who shall see worn the order which shall be mentioned below should honour those who wear it, and be encouraged to employ themselves on such customs, that by their valiance they may acquire good renown, and deserve in their time to be chosen to bear the said order; my said lord the Duke has today undertaken and founded an order which is called "the Golden Fleece," in which, with and besides the person of my lord the Duke himself, are twenty-four knights, gentlemen of name and arms without reproach, born and procreated in legal marriage, of whom a declaration of the names and surnames follows . . .

—Opening paragraph for the Charter of the Order of the Golden Fleece, founded 1430

While the Company was formed and remains active within the SCA and other reenactment groups, its members specifically strive to bring together knightly combatants, students, and practitioners of medieval martial arts. As such, they hone their skills with various weapons, attend events held by similar groups, and research related aspects of medieval life and warfare.

Tournament societies may well be a fine home for someone who wishes to actually make use of the armour in a martial art that is at once challenging and rewarding. Connected to the western ideals of chivalric conduct, the tournament serves as a mechanism to propel the combatants to conduct themselves as knights and citizens, in settings modern and medieval.

What follows is the Company's charter. On the Company of Saint George/Chronique website (http://www.chronique.com) there is a vibrant community of tournament company members and a listing of all known tournament companies.

The Great Charter of the Company of Saint George

Modern English Version by Brian R. Price
AKA SCA Brion Thornbird ap Rhys

May all know by this present charter that we the Company of Saint George do swear and declare before God our faithful obeisance unto the noble art of arms.

Whereas we declare that the true joy of combat proceeds not from the base spirit of pride, nor of vainly striving one against the other, but is only from honor.

We hereby proclaim that with God's grace this company shall endeavor to increase, advance and uphold the banner of chivalry as it was practiced by our noble ancestors, and swearing to do the same do we hereby ordain these maintenances:

That every companion shall strive through speech, manner and appearance to present forth the very mirror and example of a gentleman of Christendom.

Also that every companion shall revere such goodly arts and mysteries of days past omitting neither their practice nor their patronage.

Also that every companion shall take such care of his arms, harness, raiment and all appearances that be in accordance with his conviction that neither shame nor stain shall befall the company. And that he shall accept such guidance and counsel in regards to the above as seems meet unto the same.

Also that every companion shall endeavor to better himself in his use of arms and in all pursuits that belong to a gentleman.

Also that any who may become a companion may be in some way known to the company that his merits and advantages and be known to all.

Also that the companions shall gather no less than once per year for a special feast, with their consorts, to address the company and to administer to the same, and to share agreement together, by custom being the feasts of St. Crispen and St. George.

And also that companions be known by a red garter worn below the left knee, bearing the motto, "Honestas Supra Omnia" (Honor above all), and by a black cloak bearing a badge of the same garter worn upon the left breast.

May God serve us in our endeavor. Done this Feast of Epiphany in the year Nineteen Hundred and Ninety of our salvation at Urbs Angellorum.

Appendix

Glossary of Technical and Medieval Terms

à plaisance: A combat "of peace" held without the intent for war. The tone of the fight in an *à plaisance* encounter is generally one of friendly but earnest competition without the intent to injure, as is a common feature of its opposite, a combat held *à outrance*.

aketon: A padded garment for use under the armour, variously called a gambeson, arming coat, arming doublet, and possibly a pourpoint. Generally the garment was sewn into tubes which were stuffed and then sewn closed. The term aketon seems to have applied earlier, mostly before the 14th century, so it generally applied to the straight-cut coats worn under mail during the 11th through 13th centuries.

anachronism: Something that is "time out of place." With respect to tournament reenactments or armour the term is generally applied to elements that do not belong in their environment, such as a grille on a sallet or a basket hilt on a sword. Generally such anachronisms are adopted for reasons of recent tradition or for safety, and ideally they should be removed as more knowledge reveals the correct medieval solution for solving the same problem.

anneal: To soften metal by relaxing it under heat and allowing its crystals to realign.

anvil: A large, hard bit of steel or iron, frequently with sharp edges, used in the manufacture of swords and

armour and in blacksmithing. By the sixteenth century "horned" anvils had come to predominate over the earlier "stump" models, which can be frequently seen in manuscript illuminations.

arbor: An extension added to a motor to support a polishing or sanding wheel.

armet; armet à rondel: An Italian helmet of the 15th and 16th centuries that featured a shallow bowl, hinged cheek plates that affixed near the chin, and a moveable visor. Sometimes they were also fit with a brow reinforce and a circular rondel affixed by a post at the neck, possibly to protect against blows at the helmet's weakest point.

arming hose: Quilted hose theorized for use with armour. Sadly none survive, nor are their sufficient manuscript references at this time to ascertain the correct medieval solution. The term could also be applied to any hose worn with armour; in this case a heavy wool set of hose or chausses would seem to be correct.

articulation: The engineering required to make a joint of plate moveable.

aventail: A skirt of mail attached to a bascinet to defend the otherwise vulnerable throat and chin.

backflap: On a legharness, an extended defense for the back of the leg generally attached with a pair of hinges. The term itself is modern.

backplate: The covering of the back, generally affixed to a breastplate to form a cuirass.

ball-pien: A modern hammer featuring a flat surface on one side (the pien) and a rounded ball shape on the other, used primarily for setting rivets.

barbuta; barbute: An Italian helmet of the middle 15th century, derived from the bascinet, but with an enclosed "T" shape opening recalling Classical Greek design.

barstock: Rods or flat sections of iron or steel, often used in the manufacture of tools or helmet grilles.

bascinet: The dominant helmet of the 14th century, a "bullet" shaped defense for the head. The bascinet itself was open at the face but was fitted with various forms of visors throughout the century. Fitted with an aventail, it provided an excellent form of defense for nearly 150 years, evolving eventually into the sallet, armet, and barbute.

bastard file: A rough file used for the early stages of deburring or smoothing.

bâton: A blunt wooden sword for practice and competition within the béhourd. Used throughout the 14th and 15th centuries.

béhourd: A fighting form of the 13th through 15th centuries that utilized bâtons or clubs rather than swords, probably in an effort to reduce injury while still encouraging intense competition.

besagew: A small rondel to defend the armpit, used from roughly the end of the 14th century through the 15th.

Beverly shear: A modern version of the medieval "large" shear, used for precise manual cutting of steel shapes. Made by the Beverly Manufacturing Company of Chicago, Illinois.

bevor: A plate defense for the mouth, chin, and front of the neck often seen with a sallet during the second half of the 15th century.

bichorn, bic horn: A long cylindrical stake used to form gutter shaped defenses such as vambraces, cuisses, and greaves.

bouging: A rough smoothing phase of hammer-work designed to regularize the surface and eliminate obvious high and low spots.

breastplate: A plate defense for the front of the body, developed during the 14th century. When a backplate and faulds are added, the whole defense for the body is called a cuirass.

bries: Medieval underwear of linen.

brigandine: A defense of small plates affixed (usually with rivets) to the interior of a leather or fabric base. Brigandine construction was most popularly used for body defenses in the 14th and 15th centuries, although there are examples of gauntlets, cuisses, and other defenses made in this fashion. Brigandine defenses are relatively easy to create and offer superior defensive qualities. They are often used to reinforce underlying defenses of woven mail.

broadsword: A tapering sword wielded in one hand that was popular from roughly the 7th to the 18th centuries. The specific shape varied over time, gradually emphasizing the point over the edge as armour improved and thrusting became a more critical offensive maneuver

burr: A sharp nick of metal flashing at the edge of a piece that should be removed with a file or sanding machine.

cap à pied: A complete suit of armour, also referred to as a harness. Literally from "cap to foot."

casque: A short conical helmet, generally made from a single piece of steel with a central nasal, used throughout Europe from the 9th to the 12th centuries. Popularly known as a "Norman" cone because of the association with Norman knights throughout this period.

cervellaire: A small, close-fitting helmet generally worn under the great-helm during the 14th century. The forerunner of the bascinet, which eventually replaced it.

chamfron: A piece of plate armour defending a horse's face, connected to the crinnet that defended the neck.

chapel de fer: Literally an "iron hat." A wide-brimmed helmet of the 13th, 14th, and 15th centuries, popular especially in Britain.

chasing: The art of using tools to create a design in thin metal, working the metal into lead or pitch. Generally speaking chasing work is done from the outside, while the related technique repoussé is done from the inside.

chausse(s): The term for leg coverings, sometimes applied to cloth leggings but also applied more loosely to mail defenses worn on the leg.

chevauchée: "Slash and burn" style of warfare practiced during the Hundred Years War designed to inflict maximum economic damage on an enemy and to draw a hesitant enemy into open battle.

composite: A harness assembled of components that, strictly speaking, do not belong together. Oddly enough, this was probably common in the Middle Ages but is now considered to be a cardinal sin in the curatorial community.

coronet: A small crown worn by a member of the nobility to denote a particular rank.

cote-armour: See jupon.

cotehardie: The close-fitting outer garment of the 14th century, distinguished from earlier garments by its revolutionary form-fitting shape.

couter: Also referred to as an elbow cop, the defense for the elbow.

creasing: Placement of a sharp ridge, generally at the apex of an arched shape, to provide additional rigidity and definition.

cross-pien: A hammer with a narrow, wide face used to rapidly force metal around stakes, used extensively in flaring and raising.

cuirass: An integrated armour for the upper body consisting of the breastplate, back-plate, faulds, and tassets. The cuirass evolved from the simpler breastplate and coat of plates during the end of the 14th century, becoming dominant amongst full harnesses throughout the 15th and 16th centuries.

cuirboille: Literally "boiled leather," a general term used to describe leather hardened by heating.

cuisses: Rigid defenses for the thigh, originally of cuirboille but increasingly of plate by the third decade of the 14th century.

demi-greave: A small defense of plate transitioning the poleyn articulations to a greave on the lower leg. Sometimes no greave was worn, so the demi-greave would have been worn over a boot or chausses.

dishing: see *doming*

doming: The technique of forming metal through stretching from the inside, usually with a hammer (or in some modern shops with a press), into a sandbag or rigid depression.

effigy: A two-dimensional representation of a knight engraved into brass or bronze, often placed in church flooring during the 13th through 15th centuries. A valuable source of information on armour for a period where few physical examples remain.

embossing: The compression of metal to form shapes, either functional or decorative.

Often used on elements to provide strength and aesthetic enhancement.

engraving: Removing metal with sharp gravers to incise lines for decorative purposes.

épaules: Another term for spaulder or pauldron, the defense for the shoulder.

etching: The decorative technique in which the artist uses an asphaltum, scribing away areas to be recessed through immersion in acid.

faulds: Hoop-like defenses of plate for the hips, generally attached directly to the breastplate, placard, or backplate.

filing: Using a bastard or mill file to smooth an edge or a surface.

flaring: Hammerwork to add a flair to a metal tube or cone, used extensively in greaves, on vambraces, on helmet skirts, and for gauntlets.

fluting: Decorative and reinforcing ribbing used primarily on German armours of the late 15th and early 16th centuries.

fustian: A popular medieval fabric, possibly some kind of linen-wool cross-weave.

gambeson: A padded coat generally worn under the armour to add a layer of padding and to protect the wearer from bruising as a result of the armour pinching. Prior to the 14th century the more common term aketon was applied, while arming coat and in some instances possibly pourpoint were used in parallel during the 14th and 15th centuries.

garniture: An armour featuring interchangeable pieces for specialized use in the joust, tournament, and war, generally applied to equipment from the 16th century. Some very fine garnitures exist and still others are illustrated in decorative design books from the period.

gatling: A small defense for a knuckle, similar in function to the couter for the elbow or the poleyn for the knee.

gauntlet: An armoured defense for the hand. At first made of mail during the 11th through 13th centuries but increasingly of brigandine and plate during the 14th century. By the 15th century, whole plate gauntlets were standard throughout Europe.

gesso durro: A single reference denoting a special "durable" gesso used in the manufacture of medieval shields. Sadly the recipe for this substance remains unknown

gisant: Another word for an armoured effigy, a funeral monument featuring a knight in full array or a lady in courtly gowns.

globose: A term generally applied to breastplates of the late 14th and early 15th century, describing their characteristically rounded forms.

gorget: A defense for the neck. Generally not used before the end of the 15th century, in modern times it is often required by reenactment groups for safety reasons.

grand mêlée: A form of tournament emphasizing groups of combatants. In the earliest tourneys, these were barely distinguished from battles, but by the 15th century group encounters *à plaisance* were fought with blunted swords and bâtons accompanied by grand heraldic display.

grandguard: An added layer of plate defense worn over a couter, pauldron or arm harness, generally a specialty defense used for the joust.

great bascinet: A form of bascinet in which the aventail is replaced with plate neck defenses. A popular tournament helmet during the 15th century.

greatsword: Another term for the two-handed or longsword. In modern usage the term is generally applied to swords approaching a man's height with an extended handle.

greave: A plate defense for the lower leg, generally consisting of a front and back hinged together with a catch or strapping So-called "frontal" greaves were also used throughout the 14th and 15th centuries, and leather versions were probably the first reinforces for mail adopted during the 13th century.

grille: An open face defense for a helmet, possibly used for tournaments, sometimes applied to a bascinet of the 14th century or great bascinet of the 15th. Today the béhourd based reenactment societies tend to favor grilles on most helmets for sporting reasons, though their prevalence is far greater than was true during the medieval period.

grinding: Rough treatment to even a surface in preparation for buffing. Medieval armourers used large wheels powered by water, while modern armourers generally use electric motors.

hammer-hardening: Adding strength to an element of plate by hammering rather than heat-treating.

harness: A full suit of armour, from head to toe. See also *cap à pied*.

hastilude: An early form of tournament, generally a grand mêlée where knights fought in teams in what has been lovingly called a "simulacra of battle."

haubergeon: A shirt of mail, generally extending to the elbow and to mid-thigh.

hauberk: A full-length defense of mail for the body, legs, and arm.

heat-treating: To harden armour via heating and rapid cooling.

heaulm: Another word for the fully-enclosed helmets—generally used in the joust—worn during the 14th and 15th centuries. Many of these helmets were worn over a bascinet during the 14th century, possibly to be removed after the jousting pass was completed.

houpelande: A garment appearing near the end of the 14th century with a more flowing cut and large sleeves. A fighting version of this garment appears to have been popular in Germany, particularly for tournament use.

hundskul visor: A "hound skull" visor characteristic of the 14th century, denoting either the pointed pignose (modern) or globed dogface (also modern).

jack: A defense for the body and hips evolving from the coat of plates used during the late 15th and early 16th century. The plates in a jack were very small compared to earlier coats of plate. It is the origin of our modern term "jacket."

joust: A feat of arms in which knights with lances make passes against one another, attempting to break spears or unhorse the opponent.

jupon: Also referred to as cote-armour, the jupon was a thick padded coat designed to provide padding and to act as a defense of cloth for the upper body. Popular throughout the latter 14th century, they are often seen in manuscript illuminations from the period.

klappvisor: See *bundskul visor*.

kolbenturnier: Combat with clubs popular in 15th century Germany.

lame: A plate strip used to engineer the articulation of a joint, generally a transition plate between major components contributing to pivoting joints.

latten: The medieval term for brass or bronze; a copper alloy.

mace: A heavy club of wood or metal increasing in popularity during the 15 century, used to do damage to ever more heavily armoured combatants.

mantle: A defense that literally covers the neck and shoulder regions. In mail, the "bishop's mantel" was worn as a neck and shoulder defense throughout the 15th century. In cloth, mantling was often used to protect a helmet from the sun and to display heraldic colors.

Maximilian: A style of armour developed in the workshops of the German Emperor Maxmilian I during the first quarter of the 16th century, characterized by globular shapes, rounded flutes, and box-shaped sabatons.

mêlée: A combat involving multiple combatants.

mill file: A fine-toothed file.

occularia: An eyeslot on a helmet visor

pas d'armes: A challenge form of medieval tournament held *à plaisance*, in celebration of knighthood.

pauldron: A plate defense for the shoulder defending the shoulder point and collarbone and extending over the breast and backplates and (with lames) transitioning into the rerebrace.

pigface visor: see *bundskul visor*

placard: The lower portion of a two-piece breastplate, popular throughout the 15th century.

planish: Smoothing a metal's surface by laying multiple hammer blows to achieve an even, faceted effect.

plattner: From the German tradition, a specialty armourer working in plate. A plattner is believed to have been involved with at least the roughing out and first-pass fitting of armoured elements, probably handing off the project to lesser-skilled armourers to do the bouging, planishing, edge-rolling, fluting, and polishing.

polearm: A two-handed staff weapon featuring a heavy striking head. Increasingly popular throughout the 14th century, polearms were very effective infantry weapons when wielded by massed, disciplined troops.

poleyn: A defense for the knee, first of cuirboille and then of plate, used in the construction of a legharness.

pourpoint: An undergarment of the 14th and 15th century used to secure the legharness and chausses.

raising: A technique whereby metal is compressed over stakes, as contrasted with doming techniques, where the metal is stretched (and thinned) by working from the inside.

repoussé: An enhancement technique where thin armoured defenses are worked into pitch or lead with tools from the back to form decorative patterns on the metal's surface. Elaborate scenes were employed during the 16th century by the Negroli, Peffenhauser, and Susenhofer families.

rerebrace: A rigid defense for the upper arm, of cuirboille during the early 14th century and later of plate iron.

roping: A decorative technique to incise marks into a rolled edge, thereby achieving a rope-like effect. Popular at the very end of the 15th century and throughout the 16th.

rosette: A generic term for a small boss in the shape of a flower, either hollow or solid.

roundnose visor: See *hundskul visor*

sabaton: An armoured defense for the foot, generally of plate but in Italian armours sometimes of mail.

sallet: A characteristic helmet of the 15th century noted by its swept lower edges, especially in the tail region. The sallet probably evolved from the bascinet but gave way to the armet and close helmet at the close of the century.

slack-quenching: A form of heat-treating that relies on a slower immersion to reduce the brittleness associated with rapid cooling.

spangen construction: A technique for helmet construction whereby small plates were riveted together to achieve a larger helmet bowl. Probably employed when larger sheets of iron were difficult to obtain.

spaulder: A smaller defense for the shoulder, defending only the shoulder point, generally with lames transitioning into the rerebrace but sometimes with small lames extending upward towards the neck. Contrast with the pauldron, a larger shoulder defense also attempting to provide defense for the armpit. Note that the distinction between the two is probably modern; here it is referenced following Claude Blair's usage. Medieval ontology was much less precise, but the distinction is useful, as each describes a slightly different variation on defense for the shoulder.

sprue: A small channel cut in a mold to allow oxygen to flow, resulting in solid metal tabs that are generally removed as a roughly cased piece is cleaned up.

strapping: The process of adding straps to an armoured element to complete it for fitting to the wearer.

sugarloaf: A transitional helmet of the early 14th century featuring a sloped top—like the later bascinet—and an enclosed face like the earlier barrel helmet. No originals survive, though they are frequently pictured in manuscripts of the period. Many feature adornment of latten forming crosses below the occularium and along the front crease. A few feature moveable visors pivoted at the side.

surcoat: A heraldic coat worn over armour both for decoration and identification. It is known that surcoats were adopted during the First and Second Crusades. By the 13th century they were popular for knights in joust, tournament, and war.

tasset: A plate defense suspended by external leather straps from the *faulds*, designed to

extend the defense of the hip into the upper thigh, generally a transition between the cuirass and the legharness. Tassets, or taces as they are sometimes called, came into use during the 15^{th} century. During the 16^{th} century the tasset was actually merged with the cuisse in some harness designs, creating a cuirass and legharness in a single piece.

vambrace: An armoured element of leather or plate for the forearm, adopted during the late 13^{th} and early 14^{th} century. Also called cannons.

vervelle: A small staple, generally of latten, attached to a bascinet, armet or sallet to affix the aventail.

Sources

MODERN ARMOURERS

Note that not all of these armourers accept commissions; some work for the pleasure of the art. These armourers are noted with a *. Part time armourers are marked with a **.

Active Plattners

Wade Allen*
http://ils.unc.edu/~allen/armour.html

Greg Anderson
Mandrake Armory
P.O. Box 1551
Lawrence, KS 66044
http://www.idir.net/~mandrake/

Stirling Brown
Gravel Hill
Stretford Bridge, Leominster
Hereford, United Kingdom HR6 9DQ
http://www.servicecentre.co.uk/stirling-brown/

Michal Dabek
6871 Rawdon Boulevard
JOK 150, Rawdon
Quebec, Canada

Charles E. Davis**
Mallet d'Argent
4293 Holly Hill Road
Hubertus, WI 53023
http://www.chronique.com/Vendors/mallet.htm

James Earley**
JEARLEY@aol.com

Christian Fletcher
2825 Bright Street
Nampa, ID 83687
http://www/christianfletcher.com

Peter Fuller
Medieval Reproductions
24 County Hills Gate, NW
Calgary, Alberta, Canada T3K 5C8
http://www.medievalrepro.com

James A. Gillaspie
3102 N. Patterson
Flagstaff, AZ 86044

Jeffrey Hedgecock
Historic Arms and Armour
17228 Voorhes Lane
Ramona, CA 92065
http://www.historicenterprises.com

Tom Huguenin**
4069 Suison Valley Road
Suison, CA 94585

Brent Junkins
Anshelm Arms and Armour
7477 Nye Drive
Highland CA 92346
http://www.anshelmarms.com

Tom Justus
Eldrid Tremayne, Master Armourer
1507 Morningside Drive
Burlington, NC 27217
tjustus@sprynet.com

Robert MacPherson
520 Adam Avenue
Ithaca, NY 14850
http://www.lightlink.com/armory/armory.html

Theodore Monnich**
Chief Conservator
South Carolina State Museum
P.O. Box 100107
Columbia, SC 29202-3107

Joseph Piela
Lonely Mountain Forge
437 Houston Farm Road
Poulan, GA 31781
http://www.members.aol.com/gijchar/main.htm

Brian R. Price**
4226 Cambridge Way
Union City, CA 94587
http://www.chronique.com

Robert Valentine
Valentine Armouries
4120 8 Street, S.E.
Calgary, AB, Canada T2G 3A7
http://www.varmouries.com

Riveted Mail

Erik D. Schmid
109 Wilson Avenue SE
St. Cloud, MN 56304
http://www.chronique.com/Vendors/schmid.htm

Clothing, Dress Accessories, Shoes

Black Swan Designs
17228 Voorhes Lane
Ramona CA 92065-7109
http://www.historicenterprises/blackswan/

Max Engel**
North Star Armoury
6723 Kenyon Drive
Alexandria, VA 22307
nsarmoury@aol.com

Gaukler Medieval Wares
1052 Amphion Street
Victoria, B.C., Canada V8S 4G3
http://www.islandnet.com/~gaukler/

Doug & Amy Strong
Talbot's Fine Accessories
http://www.members.aol.com/DougStrong/talbots.html

Wasters

Hollow Earth Swordworks
1877 Oak Grove Loop
Newnata, AR 72680
http://www.hollowearthswordworks.com/

Purpleheart Armoury
6307 Lipps Lane
Houston, TX 77041
http://www.woodenswords.com/

Commercial Sources for Swords and Armour

Albion Armorers
11113 Sceptre Ridge Terrace
Germantown, MD 20876
http://albionarmorers.com/

Del Tin Armi Antiche SNC
Via dei Fabbri, 13, I-33085
Maniago PN, Italy

Museum Replicas
P.O. Box 840
Gees Mill Road
Conyers, GA 30012
http://www.museumreplicas.com

NEW TOOLS

AllCraft Tool & Supply Company
666 Pacific Street
Brooklyn, NY 11217
Some hammers, forming tools, jewelry supplies.

Anchor Tool & Supply
231 Main Street
Chatham, NJ, 07928
High-quality hammers and stakes, jewelry supplies.

AP Tool Company
201 Porter Road
Conroe, TX 77301
Blacksmith tools and forges.

Cast Specialities Corporation
P.O. Box 32
Cedarburg, WI 53012
Very inexpensive cast hammers and stakes.

Centaur Forge Ltd.
117 N. Spring Street
Burlington, WI 53105
Peddinghouse hammers, stakes, stake plates, shears, and punches.

Channellock Inc.
1306 S. Main Street
Meadville, PA 16335
#358 8 inch end nippers (for cutting rivets).

William Dixon Company
750 Washington Avenue
Carlstadt, NJ 07072
Very high-quality stake plates and stakes.

Formax Manufacturing Corporation
3178 Bellevue Street
Detroit, MI 48207
Buffing compounds, greaseless and setup abrasive

Garland Manufacturing
P.O. Box 538
Saco, ME 04072
Rawhide hammers.

General Tools Manufacturing Company Inc.
80 White Street
New York, NY 10013
#79 Automatic centerpunch, miscellaneous small tools.

The Japan Woodworker
1731 Clement Avenue
Alameda, CA 94501
Japanese "boatbuilder" hammers that make excellent planishing hammers at a good price.

Knife & Gun Finishing Supplies
Show Low, AZ 85901
Buffing compounds and wheels, various sanding tools, supplies, and knife components.

McMaster-Carr Supply Company
9630 Norwalk Boulevard
Santa Fe Springs, CA 90670
Most power tools, rawhide hammers, punches, Beverly shears, all manner of hardware.

Metalcraft Tools
Route 2, Box 366
Macclenny, FL 32063
Leather shot sandbags and autobody tools.

Meyer Machinery
B-2 blades, Whitney punches.

Missing Link Ironworks
P.O. Box 407,
Hanna, WY 82327
Oldviking@hotmail.com
Armourer's tools made from tool and spring steels. Ball, T, and creasing stakes.

National Torch Tip Company Inc.
50 Freeport Road
Pittsburgh, PA 15215-2973
Gas-Saver torch regulator for raising with a torch.

Paragon
2011 South Town East Boulevard
Mesquite, TX 75149-1122
Kilns, especially the HT-22 heat-treating kiln.

T.H. Oewthwaite Machine Company
P.O. Box 1000, 70 Koster Road
Quonset Point
Daisville, RI 02854

Oneida Air Products
1005 W. Fayette Street
Syracuse, NY 13204
Commercial-level dust management systems at a reasonable price.

Wenstrom Metalworks
Box 136
Cooper's Mills, ME 04341
Armourer's hammers, stakes, and used tools of all kinds.

Roper Whitney Co
2833 Huffman Boulevard
Rockford, IL 61103
Manufacturer of the popular #5 Junior punch and larger punches.

USED TOOLS

Also try on-line auction sites under the "blacksmith & tool" listing.

Bell Creek Iron Works
3380 W. 650 N.
Middletown, IN 47356
Used blacksmith and machine tools.

Old Tools
1221 Olympic Boulevard
Santa Monica, CA 90404

SUPPLIES

Steel & Metals

Admiral Steel
4152 W. 123rd Street
Chicago, IL 60803
Spring steel sheet.

Alaska Copper & Brass Sales
3223 6th Avenue S.
Seattle, WA 98134
Copper, brass, and sheet bronze.

Atlas Metal Sales
1401 Umatilla Street
Denver, CO 80204
Brass, bronze copper, lead, tin, zinc.

Sanding and Polishing Supplies

Knife & Gun Finishing Company
(see above)

Industrial Abrasives
642 N. 8th Street
Reading, PA 19603
Sanding belts.

Leather

Hide & Leather House
595 Monroe Street
Napa, CA 94559

Horsehair

Your local stable is the best bet, but high-quality mane and tail hair can also be purchased from:

Hitching Post Supply
10312 210th Street SE,
Snohomish, WA 98296
http://www.hitchingpostsupply.com

Rivets and Supplies

ABCD Industries
1320 Light Street
Baltimore, MD 21230

Bee Industries, Inc.
P.O. Box 347
Watertown, WI 53094
Manufacturer of solid rivets and pins.

Intra-Natl Screw & Rivet Co
6512 N. Clark Street
Chicago, IL 60626

Jebco Screw & Rivet Mfg Co
4234 W. Drummond Place
Chicago, IL 60639

Rayno Rivet Specialties Inc
2511 N. Clybourn Avenue
Chicago, IL 60614

Other

American Coal Sales, Inc.
1325 W. 9th Avenue
Denver, CO 80204
Blacksmith's coal.

American Natural Resources
P.O. Box 304
McHenry, MD 21541-0304
Metalurgical coal.

PUBLICATIONS

Apollo Magazine
22 Davies Street
London W1Y 1LH
United Kingdom

Call to Arms
1 Lyng Lane, North Lopham
Norfolk IP22 2HR
Great Britain

Chronique: The Journal of Chivalry
c/o Brian R. Price
4226 Cambridge Way
Union City, CA 94587
http://www.chronique.com

Revival
P.O. Box 168, Wellington Street
Leeds, UK LS1 1RF
Magazine for reenactors of all periods.

SPADA
Swordplay Symposium International
2657 Medill Avenue
Chicago, IL 60647
http://www.swordplay-symposium.com/

ORGANIZATIONS

A.B.A.N.A.
PO Box 206
Washington, MO 63090
314.390.2133
American Blacksmith's Association

Academy for European Medieval Marshal Arts
(A.E.M.M.A)
401–159 Frederick Street
Toronto, ON Canada M5A 4P1
416 366 1243
Online Talhoffer, training materials.

Adrian Empire
P.O. Box 46
Atwood, CA 92811
http://www.adrainempire.org

The Arms & Armour Society
Edmund Greenwood
Field House, Upper Dicker
Hailsham, East Sussex, UK BN27-3PY

Empire of Chivalry and Steel
http://www.ecs-imperial.org/

Historical Armed Combat Association
(HACA)
http://www.thehaca.com

The Jewelry Institute of America
40 Sims Avenue
Providence, RI 02909

Regia Anglorum
Kim Siddorn, 9, Durleigh Close
Headley Park, Bristol
BS13 7NQ United Kingdom
http://www.regia.org/

The Society for Creative Anachronism
Member Services
P.O. Box 360789
Milpitas, CA 95036-0789
http://www.sca.org

ONLINE RESOURCES

Arador Armour
http://www.arador.com

Armourer's Archive
http://www.armourarchive.com

Therion's Armour page
http://www.io.com/~therion1/index.html

EUROPEAN PLATTNERS

Karl Aldingen
Linzguastrasse 5
88630 Pfullendorf
Deniken, Germany

Terry English
Mellanoweth House
Black Lane, Angarrack
Hayle, Cornwall, Great Britain
TR27 5JE

Peter Leicht
The Old Barn
Thorton Le Fen
Lincoln, Great Britain
LN44 YN

Manfred Sachse
Geneickener Strasse 154
4050 Monchengladback 2, Germany

Walter Suckert
7140 Ludwigsburg
Irisweg 27, Germany

Russel Thomas **
9 St. James Close
Tooting, London, Great Britain
SW17 7RU

Appendix

Select Bibliography

Aitchson, Leslie. *A History of Metals*, London, 2 vols, 1960.

Allen, Wade, & Aaron Toman. "The Construction of early 15th century Italian Gauntlets," *The Hammer*, Vol. 12, 1981, p. 62-67.

Angier, R. H. *Firearm Bluing and Browning*. London, 1936.

Anglo, Sydney. *The Great Tournament Roll of Westminster*. Oxford, 1968.

Anjou, René. "Traité de la forme et Devis d'un Tournoi." *Editions de a Revue Verve*, Paris, 1946.

Ashbee, C.R. (trans.) *The Treatises of Benvenuto Cellini on Goldsmithing and Sculpture*. Dover, 1967.

Ashdown, Charles. *European Arms and Armour*.

Barber, Richard, & Juliet Barker. *Tournaments: Jousts, Chivalry and Pageants in the Middle Ages*. Weidenfeld & Nicholson, 1989.

Barker, Juliet R.V., *The Tournament in England, 1100–1400*. Boydell, 1986.

Blair, Claude. *European Armour*. London, 1957.

Blair, Claude, & Lionello G. Boccia, Everett Fahy, Helmut Nickel, A.V.B. Norman, Stuart W. Pyhrr, Donald J. La Rocca. Studies in European Arms and Armor: The Otto von Kienbusch Collection in the Philadelphia Museum of Art. Philadelphia, 1992.

Blandford, Percy W. *Practical Blacksmithing and Metalworking*, 2nd Ed., Tab, 1988.

Boccia, L. *Le Armature di S. Maria delle Grazie di curtatone di Mantova e L'Armatura Lombarda del '400*, Busto Arsizio, 1982.

Boccia, L. *Il Museo Stibbert a Firenze*, 2 Vols., Electra, 1975.

Boccia, L. et al. *Studies in European Arms and Armor: The Otto C. Kienbusch Collection in the Philadelphia Museum of Art Philadelphia Museum of Art*, 1992.

Borg, Alan. *Arms and Armour in Britain*. HMSO.

Boutell, Charles. *Arms and Armour in Antiquity and the Middle Ages. London*, 1871.

Boutell, Charles. *Monumental Brasses in England*. London, 1869.

Bovin, Murray. *Silversmithing and Art Metal*. Bovin, 1963.

Calvert, A.F. *Spanish Arms and Armour*. John Lane.

Chamberlain, Walter. *The Thames and Hudson Manual of Etching and Engraving*. Thames & Hudson, 1972.

Clements, John. *Medieval Swordsmanship: Illustrated Methods and Techniques*. Paladin Press, 1998.

Collura, Domenico. *Armi e armature. Cataloghi del Museo Poldi Pezzoli*, 1980.

Cosson, Baron de, & William Burgess. Catalogue of the Exhibition of Ancient Helmets and Examples of Mail. *Ken Trotman Arms and Armour Monographs 2*. Cambridge, 1985.

Cross, M. "Taking Arms Against the Knife." *New Scientist* 9, March 1996.

Crowfoot, Elisabeth, Frances Pritchard, & Kay Stanilard. *Textiles & Clothing, c. 1150–c. 1450*. Medieval Finds and Excavations in London: 4. HMSO, 1992.

Curtis, Howard M. *2,500 Years of European Helmets*. Beinfeld, North Hollywood, 1978.

Dillon, H.A. *An Almain Armourer's Album*. London, 1905.

Dillon, Viscount, & W.H. St. John Hope. *Pageant of the Birth, Life and Death of Richard Beauchamp, Earl of Warwick, KG: 1389–1439*. London, 1914.

Drobná Zoroslava, Eduard Wagner, & Jan Durdík. *Medieval Costume, Armour and Weapons*. Hamlyn, 1958.

Dufty, A.R. *European Armour in the Tower of London*. London, 1968

Edge, David, & John Miles Paddock. *Arms and Armour of the Medieval Knight*. New York, 1988.

Egan, Geoff, & Frances Pritchard. *Dress Accessories, c. 1150–c.1450*. Muesum of London Medieval Finds from Excavations in London: 3. HMSO, 1991.

Embleton, Gerry, & John Howe. *The Medieval Soldier: 15th Century Campaign Life Recreated in Colour Photographs*. Windrow & Greene, London, 1994.

Ffoulkes, Charles. *The Armourer and His Craft*. New York, 1967.

Finegold, Rupert, & William Seitz. *Silversmithing*. Chilton Book Co., 1983.

Flax, Brian. "A Comparative Study of the Gauntlets Found at the Burial of the Battle of Wisby, Gotland, July 27th 1361." *The Hammer*, Vol. 12, 1981, pp. 129–145

Flax, Brian. *The Best of The Hammer*, Vols. I & III. Raymonds Quiet Press, 1983.

Flax, Brian. "The Evolution of the Helm in the 13th and 14th Centuries." *The Hammer*, Vol. 6, 1978, pp. 53–70.

Fliegel, Stephen N. *Arms and Armor: The Cleveland Museum of Art*. New York, 1998.

Gamber, O. "Die Harnischgarnitur." *Livrustkammeren*, December 1995.

Geibig, Alfred. *Gefährlich und Schön: Eine Auswahl historischer Waffen aus den Beständen der Kunstammlungen der Veste Coburg*. Coburg, 1996.

Granscay, Stephen. *Catalogue of Armor: The John Woodman Higgens Armoury*. Worchester, MA., 1961.

Hardy, R. Allen, & John J. Bowman. *The Jewelry Engraver's Manual*. Dover, 1976.

Harmond, Adrien. *Jeanne D'Arc: Ses Costumes, Son Armure—Essai de Reconstitution*. Librarie Ernst Leroux, Paris, 1929.

Hawthorne, John G., & Cyril Stanley Smith (trans.). *Theophilus: On Divers Arts*. Dover, 1979.

Henger, G.W. "The metallography of chemical and chemical analysis of iron-base samples dating from antiquity to modern times," *Bulletin of the Historical Metallurgical Group*, iv 1970, p. 47.

Hewitt, John. *Ancient Armour and Weapons in Europe*. London, 1855.

Hoover, Herbert Clark, & Lou Henry Hoover (trans.). *Georgius Agricola: De Re Metallica*. Dover, 1950.

Hurtig, Judith W. *The Armoured Gisant before 1400*. Ph.D. thesis, Garland Publishing, 1979.

Jones, P. "The Target," *Longbow: A Social and Military History*. Cambridge, 1976.

Karcheski, Walter. *Arms and Armor in the Art Institute of Chicago*. Little, Brown, 1995.

Katalog der Leibrüstkammer, Kunshistoriches Museum, Wien Waffensammlung. Anton Schroll & Co, Wien, 1976.

Kite, Edward. *Monumental Brasses of Wiltshire*. London, 1839.

Koch, H.W. *Medieval Warfare*. New York, 1978.

Krenn, Peter. *Das Steiermärkische Landeszeughaus in Graz*, 1974.

Kunsthistorisches Museum, Wien Waffensammlung *Katalog der Leibrüstkammer*. Verlad Anton Schroll & Co, 1972.

Kutal, Albert. *Gothic Art in Bohemia and Moravia*. Polygrafia, Prague, 1971.

Lacy, Michael. *Coat of Plates to Brigandine: the Evolution of Cloth Covered Armour, 1250–1500*. Unpublished Masters thesis, 1992.

Laking, Sir Guy Francis. *A Record of European Armour Through Seven Centuries*, 5 Vols., Bell & Sons, 1920–1922.

Laking, Sir Guy Francis. *Catalogue of the Armour and Arms of the Knights of St. John of Jerusalem, now in the Palace, Valletta, Malta*. London, 1921.

Laking, Sir Guy Francis. *The Armoury of Windsor Castle*. London, 1904.

Lewton-Brain, Charles. *Cheap Thrills in the Tool Shop: Inexpensive Equipment Options and Bench Tricks for the Goldsmith*. Brain Press, Calgary, 1956.

Little, Richard L. *Welding and Welding Technology*. McGraw-Hill, 1973.

Loyen, Frances. *The Thames and Hudson Manual of Silversmithing*. Thames & Hudson, 1980.

Mann, Sir James. "A Further Account of the Armour Preserved in the Sanctuary of the Madonna delle Grazie near Mantua." *Archeologia*, 1938.

Mann, Sir James. "The Sanctuary of the Madonna delle Grazie," *Archeologia*, lxxx, pp. 117–142. (1930).

Mann, Sir James. *Wallace Collection Catalogues: European Arms & Armour*. London, 1962.

Martin, Paul. *Armour and Weapons*. London, 1967.

Meek, James B. *The Art of Engraving*. F. Brownell & Son, 1973.

Monnich, Theodore. "Iron and Steel in the Making of Armour," *Chronique: The Journal of Chivalry*, #13, pp. 45–58.

Monnich, Theodore. "Renaissance Headwear: The Art and Technology of Armour." Memphis, National Ornamental Metals Museum, 1987.

Mowbray, E. Andrew. *Arms and Armor from the Atelier of Ernst Schmidt*. Munich. Mowbray, 1967.

Newton, Stella Mary. *Fashion in the Age of the Black Prince*. Boydell, 1980.

Nickel, Helmut. *Arms and Armour Through the Ages*. Collins, 1969.

Nicolle, David. *Arms and Armour of the Crusading Era: 1050–1350*. Greenhill, 1988.

Norman, A.V.B. *Arms and Armour: Pleasures and Treasures*. Weidenfield & Nicholson, 1964.

Norman, A.V.B. "Notes on a Newly Discovered Piece of 14th Century Armour," *The Journal of the Arms and Armour Society*. Vol. VIII. No. 3, 1975, pp. 229–233.

Norman, A.V.B. & Guy Wilson. *Treasures from the Tower of London: An Exhibition of Arms and Armour*. 1982.

Norris, Malcom. *Monumental Brasses*, 2 Vols., London, 1977.

Oakshott, Ewart. *European Weapons and Armour*. Beinfeld, 1980.

Oakshott, Ewart. *Records of the Medieval Sword*. Boydell, 1991.

Oakshott, Ewart. *The Archeology of Weapons*. Lutterworth, 1960.

Peck, Stephen Rogers. *Atlas of Human Anatomy for the Artist*. Oxford, 1951.

Pfaffenbichler, Matthias. *Armourers*. Medieval Craftsmen Series, University of Toronto Press, 1992.

Phillips, John-Page. *Macklin's Monumental Brasses*. London, 1969.

Price, Brian. *The Book of the Tournament*. Chicago Spectrum Press, 1992.

Pyhrr, Stewart W., & José A. Godoy. *Heroic Armor of the Italian Renaissance: Filippo Negroli and his Contemporaries*. New York, 1998.

Reed, R. *Ancient Skins, Parchments and Leathers*. Seminar Press, 1972.

Reitzenstein, Alexander Freiherr. *Der Waffenschmied*. Eugene Sporer, 1964.

Reverseau, Jean-Pierre. *Armes Insolites du XVIe au XVIII siècle*. Musée de L'Armée, 1990.

Royal Armouries Yearbook, Vols. 1–3. HMSO 1996–1998.

Sauveur, Albert. *The Metallography and Heat Treatment of Iron and Steel*. Cambridge, MA, The Yale University Press, 1935.

Smith, Cyril Stanley, & Martha Teach Gnudi (trans). *The Pirotechnia of Vannoccio Biringuccio*. Dover, 1990.

Swiss Institute of Arms and Armour. *Rapport*, Vols. 1–4, 1972–1979.

Tholander, Erik, & Stig Blomgren. "Influence of the Ore Smelting Course on Slag Microstructures in Early Ironmaking, Usuable as Identification Basis for the Furnace Process Employed." *Scandanavian Journal of Metallurgy*, 15, 1986.

Thomas, Bruno, & Ortwin Gamber, Hans Schedelmann. *Armi e Armature Europee*. Bramante, 1963.

Thordemann, B. *Armour from the Battle of Wisby, 1361*, 2 Vols. Stockholm 1931.

Trapp, Oswald Graf, & Mario Scalini. *The Armoury of the Castle Churburg*, 2 Vols. Udine, 1996.

Trivick, Henry. *The Picture Book of Brasses in Gilt*. New York, 1971.

Union Carbide Corporation. *The Oxy-Acetylene Handbook*. Union Carbide, 1960.

Vale, Malcom. *War & Chivalry*. Athens, GA, 1981.

Waterer, John W. *Leather and the Warrior*. Museum of Leathercraft, Northhampton, 1981.

Watzel, R. "The 2000-year Tradition of the Austrian Iron and Steel Industry." *Journal of the Iron and Steel Institute*, August 1951.

Wicks, Sylvia. *Jewelry Making Manual*. Brynmorgen Press, 1991.

Wiedemar, Jack Earl Jr. *Arms and Armour in England, 1450–1471*. Ph.D. thesis. University of Pennsylvania, 1967.

Whitehead, Ross. *Buckles: 1250–1800*. Greenlight Publishing, Essex, 1996.

Wilkenson, Frederick. *Arms and Armour*. Hamlyn, 1978.

Williams, A.R. "A Technical Note on the Armour of Henry VIII and Some of His Contemporaries." *Antiquaries Journal*, 1979.

Williams, A.R. "Four Helms of the 14th century compared." *The Journal of the Arms and Armour Society*. Vol. X., No. 3, June 1981.

Williams, A.R. "Manufacture of Armour in Germany." *Waffen und Kostumkunde*, Vol. 29, No. 2, Munich, Deutscher Kenstverlag, 1987.

Williams, A.R. "Metallurgic examination of sixteenth century armour," *Bulletin of the Historical Metallurgical Group*, vi (1972), p. 17.

Williams, A.R. "On the Manufacture of Armour in 15th century Italy." *Metropolitan Museum Journal* #13, 1979.

Williams, A.R. "Problems in the Composition of Armour." *Rappor.* Institut Swisse d'Armes Anciennes, 1972, pp. 26–28.

Williams, A.R. "The Blast Furnace and the Mass Production of Armour Plate." G. Hollister Short & F.A J.L James (eds.), *History of Technology*, Vol. 16., 1994.

Williams, A.R. "The Grosschedel family of armourers of Landshut and their metallurgy *Journal of the Arms and Armour Society*, 15, 1997.

Williams, A.R. "The Knight and the Blast Furnace." *Historical Metallurgy*, August 1986.

Williams, A.R. "To What extent can forgeries be detected by metallurgical analysis: A study on some helmets." *Rapport*. Institut Suisse d'Armes Anciennes, 1976–1978, pp. 61–78.

Index

About the Author

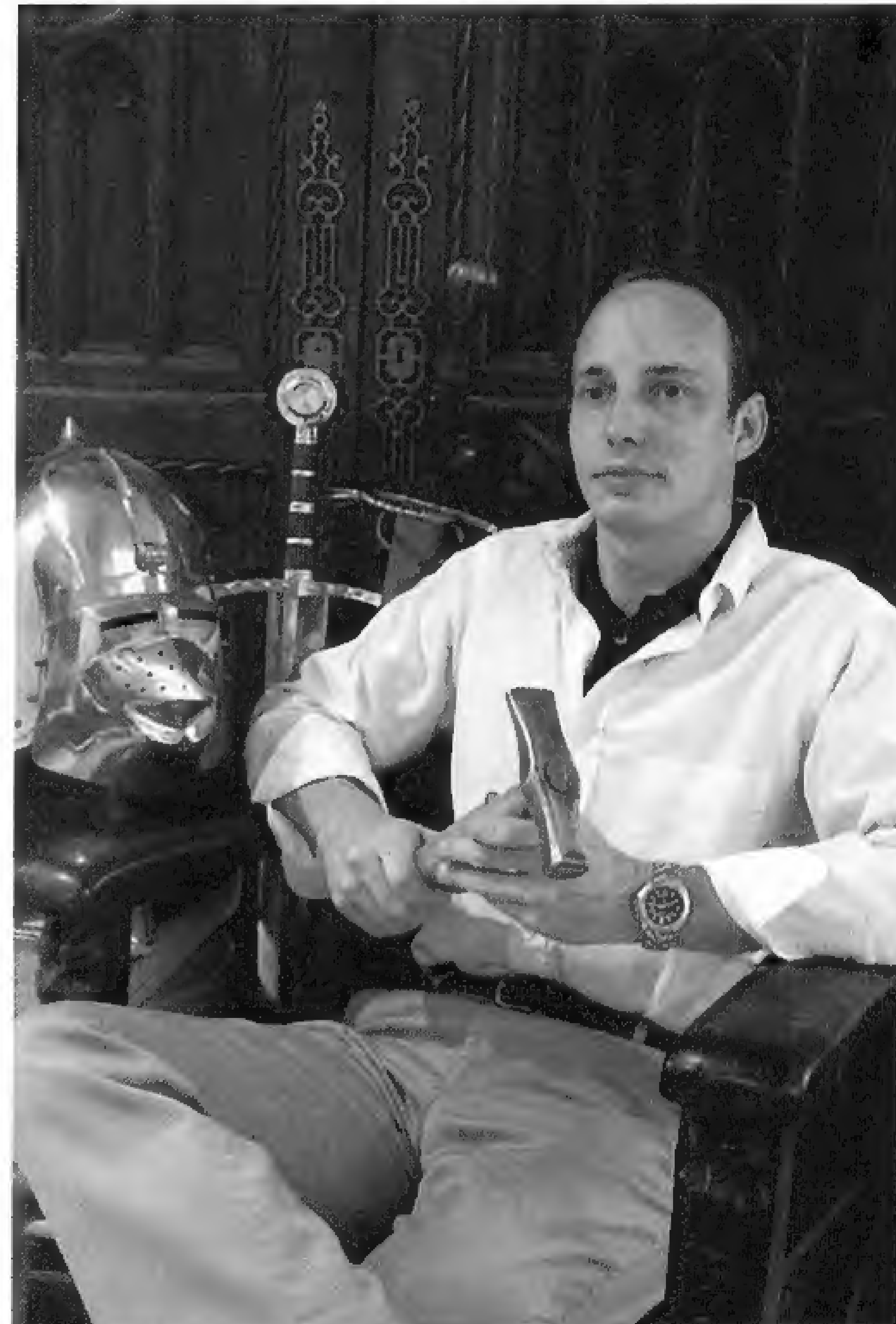
Brian R. Price has been an armourer and has practiced medieval martial arts for nearly 20 years, earning recognition both in the reenactment and educational communities for his scholarship, fighting renown, and dedication to the chivalric ideals.

Active within the Society for Creative Anachronism (SCA) and other medieval tournament societies, Mr. Price was a founder of the American Company of Saint George, a tournament society reenacting medieval feats of arms of the 14th and 15th centuries. He has worked to refine the medieval tournament as a mechanism for character development, pioneering the use of the *pas d'armes*. A prolific writer on chivalric topics, he is the editor of *Chronique: The Journal of Chivalry* and maintains the largest tournament company website at http://www.chronique.com. His previous book, *The Book of the Tournament*, has earned high praise for its quality and clarity of voice and has made him well-known in the reenactment community.

As an armourer, Mr. Price has created high-quality reproductions for reenactors, collectors, museums, and films. His company—operated during the 1980s—strove

to raise the quality of the combatant's equipment on the tournament field while also training younger armourers in the ancient craft. Today his students remain active while Mr. Price continues to armour as a matter of interest rather than profession, but his heart remains firmly rooted in the chivalric community.

Mr. Price lives in Union City, California, with his wife and two children, dividing his time between his Internet profession, family, armouring, fighting, flying, and occasionally, sleep.



Few historical icons match the evocative power of the medieval suit of armour. Forged from sheets of iron, then beaten with hammer and stake into elaborate sculptures of defense, the knight's armour symbolized his martial prowess, his social station, and his nobility of purpose—the very essence of chivalry in the Middle Ages.

Today, a growing community of medieval reenactors, collectors, historians, and martial artists have revived the art of the armourer, reanimating the steel's role as a functional defense for modern combatants participating in tournament competition as well as celebrating its beauty purely as a work of art. Through his skill, the modern armourer has succeeded in communicating across the ages, mooring the chivalric ideals of the Middle Ages to the iron sheet that is his medium, and through that sheet, to us.

Through poetic prose and practical instruction, Brian R. Price presents a lavish introduction to some of today's finest craftsmen and their work as well as a step-by-step guide for novice and intermediate armourers who desire to delve into the tools and techniques of this specialized art form. With more than 1,000 stunning photographs of medieval and modern designs, *Techniques of Medieval Armour Reproduction* is a major contribution to the restoration and preservation of one of the grandest physical representations of the ideals of the Western world.

A Paladin Press Book • ISBN 1-58160-098-4

00000

9 781581 600988

Visit our Web site at www.paladin-press.com